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STUDIES ON THE EFFECT OF HIGH ENVIRONMENTAL TEMPERATURE ON THE PHYSIOLOGICAL RESPONSE OF BUFFALO

PART I. MICRO-ANATOMY OF ENDOCRINE AND REPRODUCTIVE ORGANS OF BUFFALO COWS EXPOSED TO SUMMER CONDITIONS

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The breeding pattern of buffalo is characterized by marked seasonal variation. On the basis of informations gathered from the various farms throughout the country, buffalo has been considered as a seasonally polyoestrus animal, being sexually inactive from March to June (Rife, 1959; Whyte and Mathur, 1966); and that oestruses induced in buffaloes during summer were infertile (Goswami *et al.*, 1965). Micro-structure of the genital system, gives precise informations about the reproductive status of the female animal because gonadal hormones secreted under the influence of the anterior pituitary induce cyclic changes in the reproductive tract in accordance with the physiological needs (Dukes, 1955).

The present communication deals with the microanatomy of anterior pituitary and the reproductive organs of buffalo cows to gain factual information about their status during the summer months. Since it has also been shown that the reproductive rhythm in the female can proceed normally only in euthyroid individuals (Nalbandov, 1958) the scope of the investigation was extended to include the thyroid gland as well.

MATERIALS AND METHODS

The investigation was carried out during April, May and June, which represent the hottest part of the year at Mathura. The housing and management of the two groups of animals utilized in this study was as below :

(i) Six empty and dry buffalo cows (age five to eight years) under conventional management (unprotected group) were allowed to wallow for about half an hour before 7·00 a.m. and then sent out to the grazing area, which was practically denuded of vegetation and sparsely populated with trees, for six to eight hours. On their return to the farm premises, they were kept confined to a walled yard.

(ii) Buffalo cows of the similar age and weight, selected on paired basis with those mentioned above (protected group) were housed from 7 to 19 hours in a metabolic stall provided with four electric fans and two air coolers. Five pairs of windows fixed on the two opposite walls, for cross ventilation, were fitted with thick mats woven out of the roots of Andiopogan muricatus. This material has the power of retaining water when it is allowed to run over the mats. When strong hot wind blow through the mat the evaporation of water brings about considerable reduction in the room temperature. Locally these are known as khas tatties; the contraption in a different form is also known as "desert cooler". The set up effectively prevented rise of ambient temperature above 92°F even on the hottest days when the outside temperature could go beyond 115°F. In order to provide further comfort, the animals were given shower baths at 8, 12, 15 and 18 hours. During the night buffaloes were kept in an open yard.

Both in the morning and evening, wheat straw was put in the mangers and drinking water was offered ad lib. In addition each animal was offered daily 5 kg of green fodder, and 2 kg of a concentrate mixture containing 25% each of crushed gram, barley, bran and groundnut cake, fortified with 1 oz. of mineral mixture.

The climatic elements obtaining in the metabolic stall and outside were determined according to methods described by Lee (1953). The pertinent data have been collected in table 1.

TABLE 1

Climatic data recorded at 4·00 p.m.

Monthly mean	Air temperature	Surface temperature	Reflected radiation K. Cal./sq.m/hour	Light intensity Lux units	Air movement ft./minute	Relative humidity
(a) *Outside environment (unprotected animals).*						
April	96·40	114·65	42·4	N.R.	300·00	56·10
May	105·60	125·50	66·0	N.R.	281·20	54·00
June	107·50	129·20	89·2	N.R.	192·50	44·50
Seasonal mean	103·20	123·10	65·9	N.R.	257·90	51·50
(b) *Environment in experimental house (Protected Animals).*						
April	85·50	76·70	nil	21·00	121·50	52·30
May	89·90	77·40	nil	27·00	122·70	50·00
June	91·50	80·10	nil	28·20	127·00	51·30
Seasonal mean	88·90	77·90	nil	25 40	123·60	51 30

Temperature was recorded in Farenheit.
N. R.=Not recordable as it was beyond the range of the instrument.

The protected animals were watched at six to eight hourly interval every day for the presence of vaginal discharge. Those animals where it was observed were considered to be in heat and the fact was verified by the mounting behaviour of a bull trained to locate animals in oestrus and also through palpation of the reproduction organs per rectum. For the detection of heat in the unprotected animals a trained bull was brought in the herd every day in the morning and evening. Oestrus record of all the animals is given in table 2.

TABLE 2

Incidence of oestrus in unprotected and protected buffalo cows during summer

Brand No.	Date in oestrus
Unprotected animals	
34	15.5.65; 5.6.65
8	25.5.65; 15.6.65
3*	9.5.65; 4.6.65; 28.6.65
48*	8.5.65; 30.5.65; 21.6.65
1*	7.5.65; 26.5.65
15*	30.5.65
Protected animals	
7	6.4.65; 28.4.65; 29.5.65; 19.6.65
2	23.4.65; 14.5.65; 2.6.65
9	6.5.65; 28.5.65; 17.6.65
2	10.4.65; 18.4.65; 9.5.65; 1.6.65; 23.6.65
44*	20.4.65; 10.5.65; 31.5.65; 21.6.65
54*	15.4.65; 18.4.65; 8.5.65; 30.5.65; 21.6.65

* Animals slaughtered

Two animals from each group found in oestrus when the heat stress was at its maximum and two more animals from the unprotected group, not in oestrus, were slaughtered. The pituitary, thyroid and all the reproductive organs were dissected out and small pieces of the tissues were fixed in 4% neutral solution of formaldehyde in normal saline for a week. Washing, dehydration, cleaning, paraffin-embedding and section cutting of tissues were carried out as described by Carleton and Leach (1949). Sections were stained by haemotoxylin and eosin. The height of the epithelium of the various organs and the size of the thyroid follicles were determined by using micrometers.

OBSERVATIONS AND DISCUSSION

1. *Anterior pituitary:* In unprotected buffalo cows, not exhibiting the sexual cycle for nearly five weeks and not in oestrus when slaughtered, the organ

was characterized by a random distribution of acidophilic cells which constituted the greater proportion of the cell mass. At many places cytoplasmic granules were distinctly visible. Basophils were seen in clustors at various places and had homogeneous cytoplasm. The chromophobes were comparatively less in number (Fig. 1a). In buffaloes slaughtered during oestrus (whether protected or unprotected) the gland became conspicuous by containing comparatively more basophilic cells arranged in clusters and vacuolation was observed in their cytoplasm. As the basophilic cells are believed to produce gonadotrophins (Asdell, 1957) the observed physiological vacuolation could be associated with the discharge of the gonadotrophic hormones because the animals were in oestrus when they were slaughtered. The chromophobes were again fewer in number (Fig. lb).

2. *Thyroid:* In animals of the unprotected group not in oestrus, the size of the follicles was comparatively less than in animals which were in oestrus and the diameters ranged between 55 to 170 μ. Cuboidal epithelium (average height 5·5 μ) lined the follicles which were completely filled with colloid. Numerous cells were also seen in the interfollicular zone (Fig. 2a). The glands of the animals in oestrus irrespective of group, had numerous large follicles (diameter 350 μ) packed with colloid. The epithelium (average height 3·0 μ) had a flattened outline. Very little interfollicular stroma and parafollicular cells were seen (Fig. 2 b). The picture indicated that the release of the hormone from the gland was somehow inhibited resulting in an excessive accumulation of colloids in the follicles causing flattening of the epithelium. As these animals were in oestrum, it was quite probable that the change in the thyroid picture could be due to the inhibition of the thyrotropic potency of the anterior hypophysis under the influence of oestrogen as suggested by Kar and Ghosh (1950). What emerged as of importance relevant to the investigations under reference from the histology of the thyroid in the unprotected buffaloes was the absence of any abnormality in the glandular architecture and it in no way indicated that the gland activity was adversely affected by the "summer stress". Such a conclusion was further supported by the level of circulating protein bound iodine (Pandey, 1967). Hence, it could be inferred that the thyroid is not involved in the reported reproductive quiescence in buffalo cows during summer.

Ovaries: While in the unprotected animals, not in oestrus, there was no corpus luteum but the ovaries had numerous follicles at various stages of development with degenerative changes in the granulosa cells in some of the follicles (Fig. 3a), those in oestrus the ovaries, irrespective of group, were characterized by the presence of fully developed follicle in one of the ovaries along-side a large corpus luteum which was either in the same or in the other ovary. The ovum could not be seen in the follicles as it may have been washed away after the rupture of the follicle. The luteal cells did not present a typical cord like arrangement instead they were discretely disposed, with loose connective tissue. The cytoplasm showed some vacuolation. The general picture was that of a degenerating corpus luteum. The connective tissue surrounding the corpus luteum was highly vascularized. Few atretic follicles were present (Fig. 3b).

Fallopian tube—In the unprotected animals, not in oestrum, the mucus membrane had branched longitudinal folds. Epithelium was mainly ciliated columnar type but in a few regions it was pseudostratified columnar (average height 21·5 μ). Lamina propria was thin, predominantly made up of fibres with few fibroblastic cells. Muscularis mucosa and submucosa were absent. Muscle layer was moderately thick, mostly composed of longitudinal bundles (Fig. 4a). During oestrus, in animals of either group, folding of mucus membrane was pronounced; practically filling up the lumen of the tube (Fig. 4b). The epithelium was mainly tall, ciliated, pseudostratified, columnar and cilia were abundant (average height 35·0 μ). Occasionally intraepithelial cysts could be seen. Lamina propria contained more cellular than fibrous tissue, but in general it was reduced to a narrow strip so that the basal surface of the epithelial cells were very close to each other.

Uterus: In unprotected animals, not in oestrus, uterine epithelium was simple columnar or at places, pseudostratified columnar (average height 14·0 μ). The endometrial stroma was dense and cellular. The glandular region was narrow with small glands appearing as solid epithelial cords (Fig. 5a). During oestrum, in animals of either group, the surface epithelium appeared taller and there were goblet type cells intermixed with the pseudostratified columnar epithelium (average height 21·5 μ). Glandular development was very marked and the glands were lined with simple columnar cells and showed secretary activity. The large ducts of the glands were lined with pseudostratified columnar epithelium (Fig. 5b). The endometrial stroma and myometrium were loosely arranged and were oedematous. These regions also showed marked hyperaemia.

Cervix: In the unprotected animals, not in oestrum, the endometrial foldings were not pronounced and had only few secondary folds. The surface epithelium was of simple columnar type (average height 7·0 μ). The stroma was compact and fibrocellular (Fig. 6a). During oestrum in animals of either group the endometrial folds were conspicuous and had many secondary folds. The surface epithelium had been transformed to tall columnar or pseudostratified columnar with numerous mucus cells (average height 21·0 μ). The stroma was oedematous and contained numerous blood vessels. Another noticeable change was the prominance of collagenous fibres with wavy arrangement. Muscular layer did not reveal appreciable change (Fig. 6b).

The gross anatomical (Fig. 7a and 7b) and the histological characteristics of the reproductive tract in either of the two groups of buffalo cows, when in oestrus, were manifestations of normal reproductive rhythm (Dukes, 1955) and lend no support to the view that buffalo cows are sexually inactive during the summer months. Roy *et al.,* (1968) have reported over 80% fertility in buffaloes bred during the summer season. Similar observations have also been reported from localities like Ludhiana and Warangal separated by hundreds of miles where investigations to assess the success of breeding operations carried out during the summer season have been conducted through a project sponsored by the Indian Council of Agricultural Research. The successful breeding operation of buffaloes during the summer reported from widely scattered centres is not at all unexpected in the context of the observations made during the course of the study reported in the present communication.

SUMMARY

Micro-anatomy of the anterior pituitary, thyroid and reproductive organs had been studied in order to evaluate the reproductive status of buffalo cows maintained exposed to and protected from the summer conditions and when they were in oestrus or otherwise.

The anterior pituitary had more basophilic cells, in buffalo of either groups, when they were in heat; difference observed can be associated with oestral changes.

The micro-structure of the thyroid, in unprotected animals, did not indicate any deviation from normal. It can, therefore, be inferred that the thyroid is not involved in the reported reproductive quiescence in buffalo cows during summer.

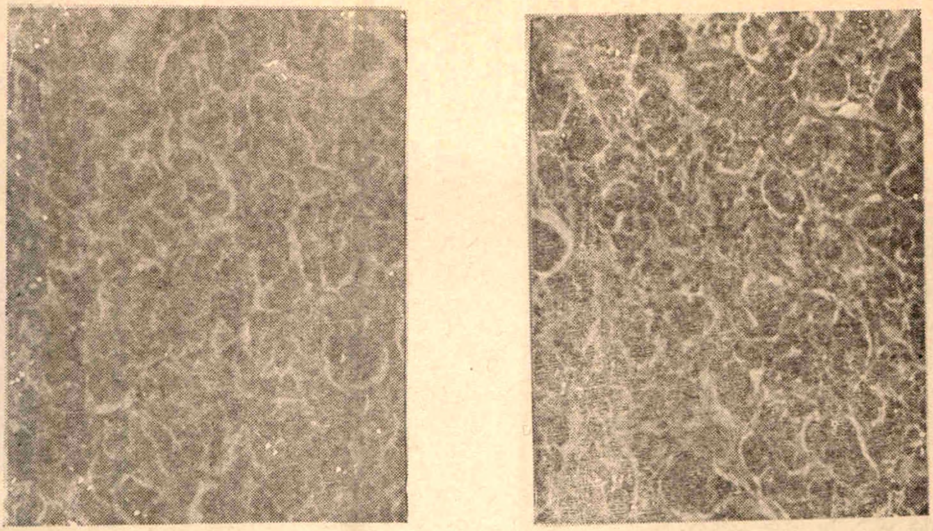
The histological architecture of the reproductive organs of buffalo cows in heat during summer, whether protected or unprotected, was typical of what it should be during normal oestrum; there was no indication of any deviation. The study lend no support to the view that buffalo cows are sexually inactive during summer.

ACKNOWLEDGEMENT

Our thanks are due to Sri C.V.G. Choudary, Principal, U.P. College of Veterinary Science and Animal Husbandry, Mathura for providing necessary facilities.

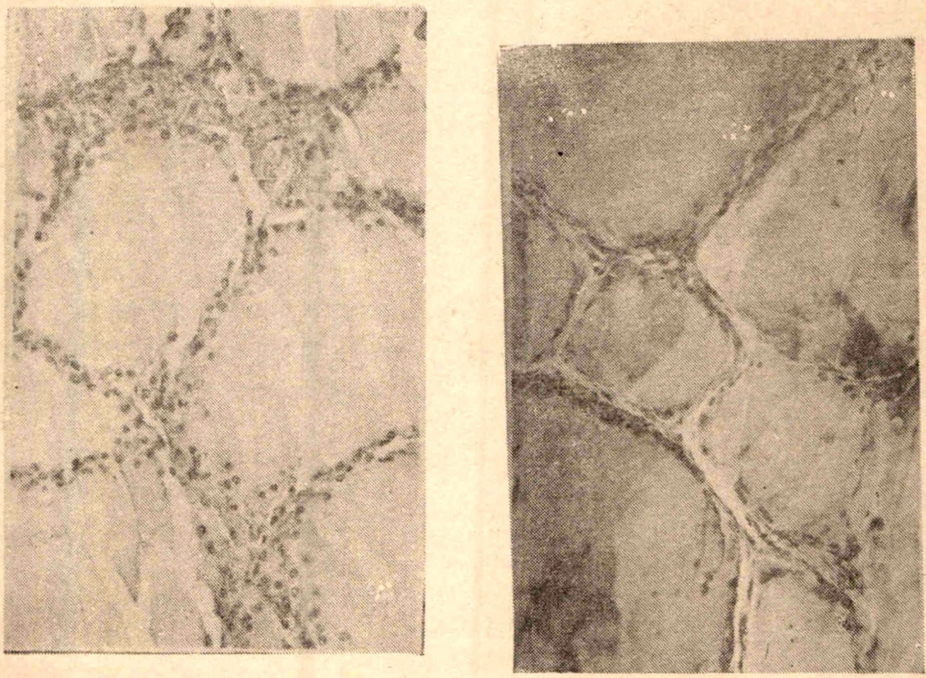
REFERENCES

1. Asdell, S. A. 1957. Reproductive Hormones, Physiology of Farm Animals, **3**: Ed. Hammond, J., Butterworths Scientific Publications, London.
2. Carleton, H. M. & Leach, E. H. 1949. Schafer's Essentials of Histology, Longmans Green & Co., London.
3. Dukes, H.H. 1955. Physiology of Domestic Animals, Comstock Publications, N.Y.
4. Goswami, S. B.; Luktuke, S. N. & Nair, A. P. 1965. *Ind. Vet. J.*, **42**: 410.
5. Kar, A.B. & Ghosh, A. 1950. *Ind. J. Physiol.*, **6**: 25.
6. Lee, D.H.K. 1953. Manual of Field Studies on the Heat Tolerance of Domestic Animals, FAO Development Paper No. 38. FAO of United Nations, Rome, Italy.
7. Nalbandov, A.V. 1958. Reproductive Physiology, W.H. Freeman & Co., San Francisco.
8. Pandey, M.D. 1967. Role of Environmental factors on the Water and Electrolyt-Metaboilsm -and Productivity of Buffalo cows, Ph.D. Thesis, Agra University, Agra.
9. Rife, D.C. 1959. Water Buffaloes of India and Pakistan, Internat. Cooper. Adminis., Washington, D.C.
10. Roy, A.; Raizada, B.C.; Tewari, R.B.L.; Pandey, M.D.; Yadav, P.C. & Sengupta, B.P. 1968. *Ind. J. Vet. Sci.*, **38**: 554.
11. Whyte, R.O. & Mathur, M.L. 1966. *Ind. Dairyman*, **18**: 161.



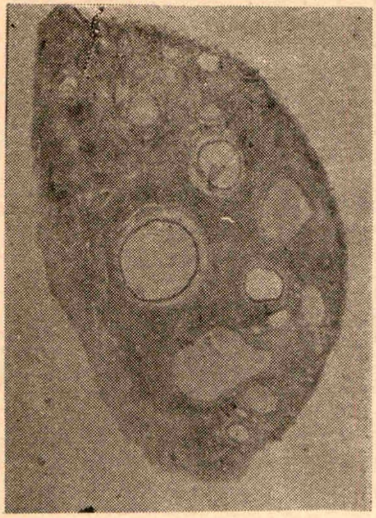
1 (a) 1 (b)

Fig. 1. (a) Anterior pituitary of buffalo cow not in oestrus (x250).
Fig. 1. (b) Anerior pituitary of buffalo cow in oestrus (x280).



2 (a) 2 (b)

Fig. 2. (a) Thyroid of buffalo cow not in oestrus (x400).
Fig. 2. (b) Thyroid of buffalo cow in oestrus (x400).



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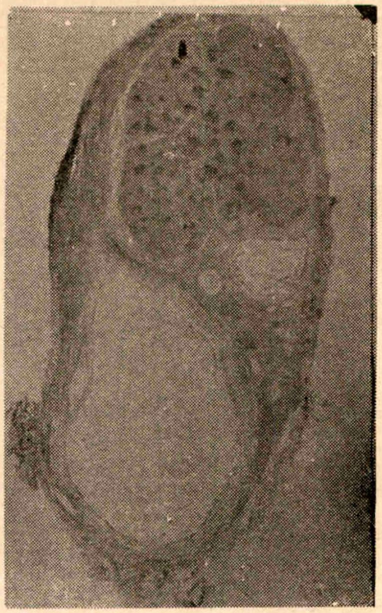
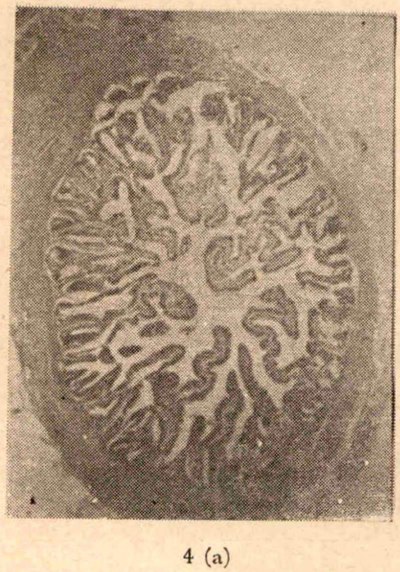


3 (b)

Fig. 3. (a) Ovary of buffalo cow not in oestrus (x4).
Fig. 3. (b) Ovary of buffalo cow in oestrus (x4).



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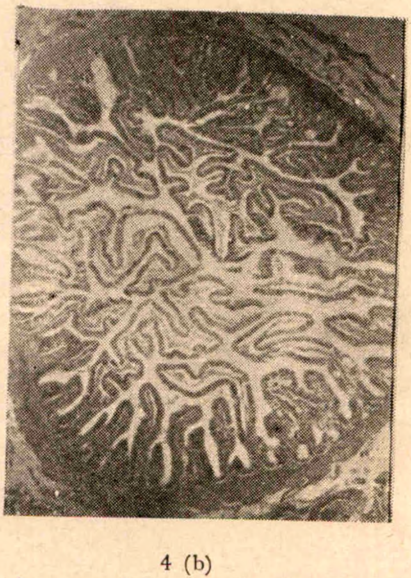
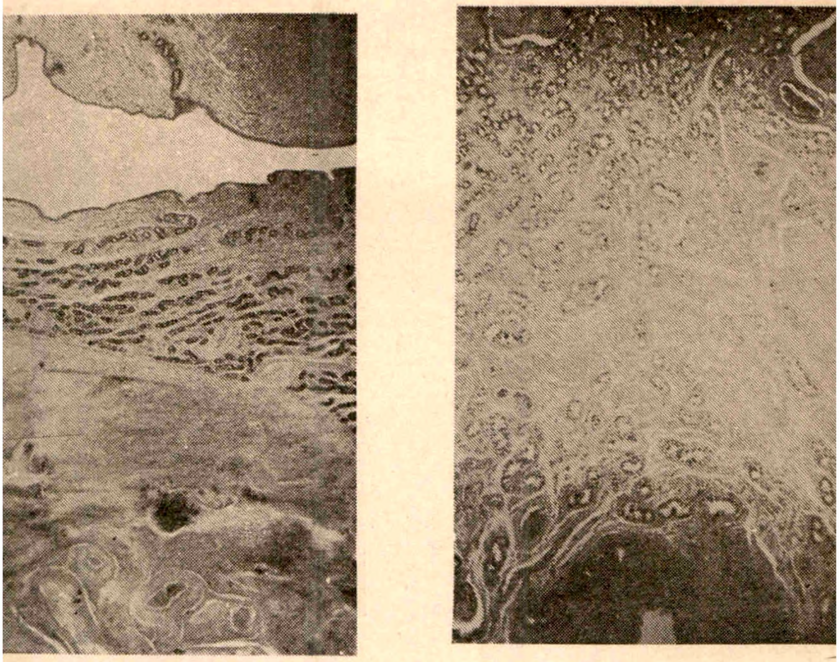


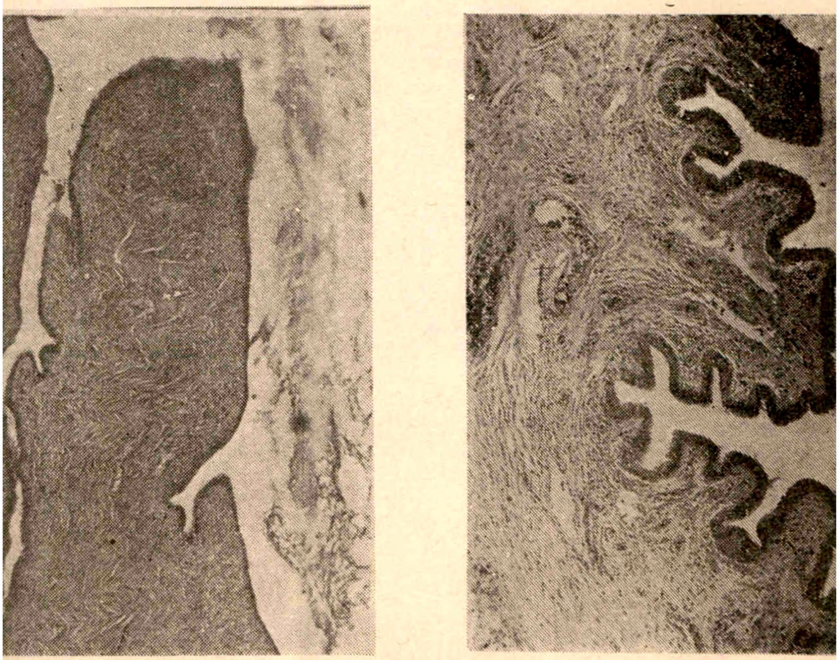
4 (b)

Fig. 4. (a) Fallopian tube of buffalo cow not in oestrus (x28).
Fig. 4. (b) Fallopian tube of buffallo cow in oestrus (x28).



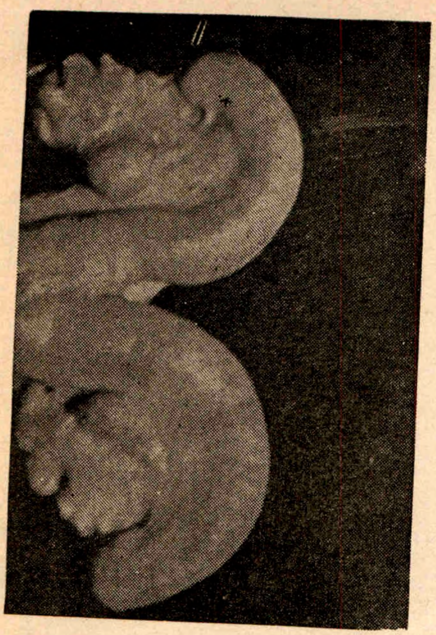
5 (a) 5 (b)

Fig. 5. (a) Uterus of buffalo cow not in oestrus (x28).
Fig. 5. (b) Uterus of buffalo cow in oestrus (x28).



6 (a) 6 (b)

Fig. 6. (a) Cervix of buffalo cow not in oestrus (x70).
Fig. 6. (b) Cervix of buffalo cow in oestrus (x70).



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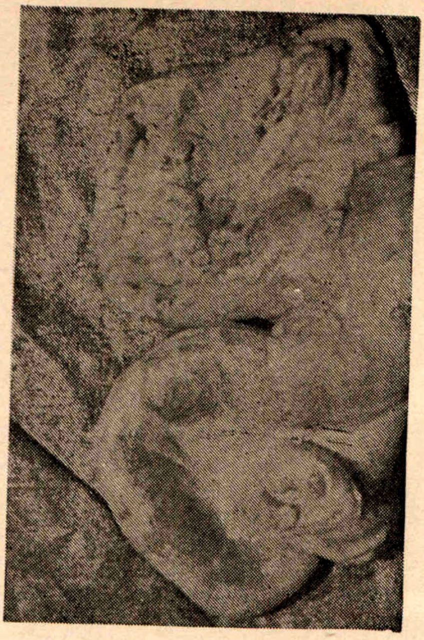

7 (b)

Fig. 7. (a) Genital organs of buffalo cow not in oestrus.

Fig. 7. (b) Genital organs of buffalo cow in oestrus.

RESPONSE OF WHEAT TO SOURCES AND LEVELS OF NITROGEN

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The element Nitrogen is found deficient for the growth of wheat in the cultivated soil. Artificial nitrogenous fertilizers constitute a good source to meet this deficiency. Experiments were conducted to assess the relative efficacy of the application of such fertilizers on growth, development and yield of wheat under field conditions. An attempt has also been made to suggest a suitable fertilizer for wheat cultivation keeping in view the economics involved.

Review of Literature

Vaidyanathan (1933); Bajpai (1951) and Chandnani (1954) have reported increased yields of wheat by the application of ammonium sulphate. Chandnani (1954) reported increased yield by the application of ammonium sulphate, ammonium sulphate nitrate, Urea and chillian nitrate. Experiments with wheat under the fertilizers use projects (Anonymous, 1959) revealed that only under irrigated conditions ammonium sulphate was found better than urea. However, Gupta and Das (1962) reported more profitable results by the use of urea than with ammonium sulphate. Mehrotra (1963) reported a better yield with ammonium sulphate nitrate than with ammonium sulphate and urea.

Results of work done on wheat in Uttar Pradesh area for a decade from 1951 to 1961 revealed that there is no unanimity regarding the best source and the optimum dose of nitrogen (Agrawal, 1951; Mitra, 1955 and Gautam, 1961).

Materials and Methods

Two experiments were conducted on wheat during the rabi season of 1961-62 and 1962-63 at the Students' Instructional Farm, Government Agricultural College, Kanpur with three sources of nitrogen, namely, urea, ammonium sulphate and ammonium sulphate nitrate applied at the rates of 0, 30 and 60 lb nitrogen per acre. A factorial 3 × 3 experiment with randomised block design was laid out having net plot of 1/56·7 acre. The treatments were replicated four times. *Jowar* crop was grown in the preceeding *Kharif* seasons.

The experimental plot had sandy loam soil containing 0·056 per cent total nitrogen and a pH of 7·2 before sowing the wheat crop. The pH of the soil remained constant even after experimentation. The field was thoroughly prepared after *palewa* (Pre-irrigation) and finally laid out. At the time of sowing the required fertilizers were evenly spread in the plots. Thirty-five seers of wheat were sown per acre on November 5, 1961 in the first experiment and on

November 2, 1962 in the second experiment. The crop was irrigated three times during its life cycle.

Growth observations, such as, the height of main shoot, number of tillers, length of ears, number of grains per ear and grain and straw yield were recorded. Yield per hectare was also calculated.

RESULTS AND DISCUSSIONS

The effects of the main treatments and their interactions on grain and *bhusa* yield of wheat are presented in table 1 and tables 2 and 3 respectively. Further, growth and developmental characters under the effects of main treatments are given in tables 4 and 5.

TABLE 1

Effect of different sources and levels of nitrogen on yield of grain and bhusa in wheat in experiment 1 and 2 (Kg. per hectare)

Sources of nitrogen	Grain		Bhusa	
	Experiment 1	Experiment 2	Experiment 1	Experiment 2
1. Urea	1426·916	1850·030	3149·250	3905·811
2. Ammonium sulphate nitrate	1590·433	1863·862	3265·587	3678·571
3. Ammonium sulphate	1492·374	1764·568	3297·944	3849·742
C.D. at 5%	109·396	...	...	...
C.D. at 1%	147·088	...	...	...
Nitrogen (lb. per acre)				
0	837·824	1394·809	1637·363	2842·970
30	1598·584	1936·727	3295·227	4005·352
60	2072·577	2300·805	4730·791	4825·886
C.D. at 5%	109·396	291·287	473·791	731·045
C.D. at 1%	147·088	394·928	598·678	981·182

TABLE 2

Effect of interaction of sources and levels of nitrogen on grain and bhusa yield (Kg. per hectare) of wheat in experiment 1

Sources	Levels of nitrogen (lb. per acre)					
	Grain			Bhusa		
	0	30	60	0	30	60
Urea	805·220	1588·704	1886·833	1744·314	3446·885	4256·304
Ammonium sulphate nitrate	990·717	1505·465	2275·117	1465·451	3279·419	5051·891
Ammonium sulphate	717·535	1702·077	2056·275	1702·571	3307·330	4867·135
C.D. at 5%	184·484			747·916		
C.D. at 1%	261·523			874·874		

TABLE 3

Effect of interaction of sources and levels of nitrogen on grain and bhusa yield (Kg. per hectare) of wheat in experiment 2

Sources	Levels of nitrogen (lb. per acre)					
	Grain			Bhusa		
	0	30	60	0	30	60
Urea	1388·140	1990·940	2179·034	2801·474	4001·153	4909·866
Ammonium sulphate nitrate	1264·640	1997·489	2300·805	2720·705	4223·453	4832·555
Ammonium sulphate	1498·549	1798·407	2062·944	3007·546	3804·541	4739·189
Non-sig.	...	...	...	...	...	...

TABLE 4

Effect of different sources and levels of nitrogen on growth and developmental characters of wheat in experiment 1

Characters	Levels of nitrogen (lb. per acre)			C.D. 5%	C.D. 1%	Sources of nitrogen			C.D. 5%
	0	30	60			Urea	Ammonium Sulphate nitrate	Ammonium Sulphate	
1. Height of main shoot after 135 days (cm.)	74·93	94·00	105·0	4·54	6·15**	97·35	103·0	102·5	4·54
2. No. of tillers per plant after 135 days	1·27	2·08	2·82	0·18	0·25**	1·91	2·2	2·25	0·18
3. Ear length (cm.)	5·92	7·02	7·46	0·47	0·64**	6·84	6·94	6·92	N. S.
4. No. of grains per ear	25·7	33·4	39·7	2·58	3·49**	31·6	33·4	32·8	N. S.
5. Fertility ratio	49·4	59·2	67·1	2·68	3·62**	57·3	58·7	58·8	N. S.
6. Grain yield per plant (gm.)	1·48	2·94	3·91	1·02	1·39**	2·72	2·84	2·76	N. S.
7. Straw yield per plant (gm.)	4·77	8·06	11·03	2·35	2·61**	7·8	8·1	8·3	N. S.

** Significant at 1% level.

TABLE 5

Effect of different sources and levels of nitrogen on growth and developmental characters of wheat in experiment 2

Characters	Levels of nitrogen (lb. per acre)			C.D. 5%	C.D. 1%	Sources of nitrogen			C.D. 5%
	0	30	60			Urea	Ammonium Sulphate nitrate	Ammonium Sulphate	
1. Height of main shoot after 135 days (cm.)	94·40	103·95	107·4	5·56	7·52**	102·4	102·4	100·7	N. S.
2. No. of tillers per plant after 135 days	1·86	3·01	4·03	0·63	0·83**	3·06	3·01	2·83	N. S.
3. Ear length (cm.)	7·40	8·02	9·03	0·38	0·43**	8·24	8·04	8·25	N. S.
4. No. of grains per ear	32·30	36·85	41·58	1·52	2·06**	36·64	36·87	37·22	N. S.
5. Fertility ratio	59·92	66·03	70·10	2·82	3·83**	65·21	65·40	65·47	N. S.
6. Grain yield per plant (gm.)	2·70	3·92	6·05	0·74	1·00**	4·19	4·31	4·16	N. S.
7. Straw yield per plant (gm.)	6·75	10·70	14·41	1·67	2·65**	10·55	10·83	10·48	N. S.

** Significant at 1% level.

Sources of nitrogen—Different sources of nitrogen did not produce consistent results in both the years, although grain yield was more with ammonium nitrate than with other sources of nitrogen in experiment 1 (Table 1). This is in confirmity with the findings of Mehrotra (1963). In both the experiments the yield of *bhusa* (Table 1) and growth characters (Table 4 & 5) did not differ due to different sources of nitrogen except the height of the main shoot and the number of tillers became reduced in experiment 1 when urea was applied.

Doses of nitrogen—In both experiments grain and bhusa yield increased with the increase in the dose of nitrogen applied to the soil (Table 1). The other growth characters (Tables 4 & 5) also exhibited similar trends. Thus, height of main shoot, number of tillers, length of ear, number of grains per ear, fertility ratio and grain and straw yield per plant also increased with the increase in the concentration of nitrogen indicating the efficacy of nitrogen application for increasing the yield of wheat. Similar increase in yield with the increase in the doses of nitrogen has been reported in wheat by other workers (Relwani, 1960 and Gautam, 1961).

Interaction—The effect of interaction of different sources and levels of nitrogen was significantly high with regard to grain and *bhusa* yield of wheat in experiment 1, the maximum attained being with 60 lb. nitrogen per acre in the form of ammonium sulphate nitrate in both the experiments.

Economics of manuring—To work out the economics of using these fertilizers for wheat it is necessary to determine the response to applied nitrogen more elaborately. However, an attempt is made here to work out the economics of manuring with the data available. Response equations[1] computed for wheat grain and bhusa are given below:

$$Y_g = 6111\cdot6 + 25\cdot6032\,X - 0\cdot1294\,X^2 \qquad \text{(i)}$$

$$Y_b = 2233\cdot2505 + 53\cdot0807\,X - 0\cdot1795\,X^2 \qquad \text{(ii)}$$

Y_g and Y_b are expected yields of wheat grain and bhusa in kg. per hectare respectively and X denotes the level of nitrogen application per acre. These equations are quadratic indicating diminishing efficiency of nitrogen in the duction of wheat, when increasing doses of nitrogen are applied to the same It clearly indicates that each additional unit of nitrogen contributes less ield than the preceding unit. The observed and expected yield of wheat *bhusa* worked out by use of quadratic equations (i) and (ii) are given

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quations have been fitted by Method of least squares. Mills F.C., thods applied to Economics and Business Henery Holt & Company, 9. Chap. X.

TABLE 6

Observed and expected yield of wheat grain and bhusa Kg. per hectare

Levels of nitrogen in lb. per acre	Grain		Bhusa	
	Observed	Expected	Observed	Expected
0	1116·341	1116·341	2240·166	2236·250
10		1359·431		2718·931
20		1576·635		3223·038
30	1767·729	1767·954	3650·314	3664·049
40		1933·387		4069·171
50		2072·935		4290·167
60	2186·789	2186·602	4778·486	4771·649

The yield of wheat grain as well as of *bhusa* increased with the increase in the dose of nitrogen but at a decreasing rate indicating the response of wheat to nitrogen within stage II of production. No economic decisions can be made without the knowledge of the price of wheat grain, *bhusa* and the fertilizer. A recommendation for the optimum rate of nitrogen application can be made by equating the value of the additional yield (grain and bhusa) to the additional cost of nitrogen. This relationship is shown in table 7.

TABLE 7

Economics of nitrogen application to wheat

Levels of nitrogen (lb/acre)	Additional N. (lb/acre)	Total yield (Kg./hectare)		Additional yield (Kg./hectare)		Additional return (Rs.)		Total	Additional cost of N/ha
		Grain	Bhusa	Grain	Bhusa	Grain	Bhusa		
0	...	1116·34	2233·25	...	...	...	...	...	
10	10	1359·43	2718·93	243·08	658·69	104·92	41·29	146·92	
20	10	1576·63	3223·03	317·20	473·40	93·76	38·80	132	
30	10	1767·95	3664·04	191·31	441·01	82·59	35·02	1	
40	10	1933·38	4069·17	165·43	405·10	71·40	32·77		
50	10	2072·93	4290·16	139·54	369·19	61·60	29·86		
60	10	2186·60	4771·64	113·66	333·27	49·05	26·97		

1. Yield data in the table are averages for the year 196
2. Wheat grain @ 16·00 per md. (37·06 Kg.).

3. Wheat Bhusa @ 3·00 per md. (37·06 Kg.).
4. Nitrogen @ 77 Paise per lb. (Average price of the three nitrogenous fertilizers).

It is clear from the above table that by application of the first 10 lb. of nitrogen per acre, a farmer may receive Rs. 146·92 per hectare for Rs. 19·01 spent on nitrogen. It is clearly profitable to increase the application of nitrogen upto 60 lb. N per acre. By application of 60 lb. nitrogen per acre to wheat crop one may obtain a return of Rs. 76·50 per hectare for Rs. 19·01 spent on nitrogen. Farmers with sufficient capital may fertilize wheat upto 60 lb. N and can make high profit. However, farmers with limited capital resources may choose any rate of application below 60 lb. N per acre, consistent with their expectations in price fluctuations and yield variability. Chandnani et al., (1960) also found maximum profit by applying 60 lb. N per acre to wheat crop.

Since the effect of sources of fertilizers was not consistent in different years, it seems worthwhile to compare the efficiency of different fertilizers in terms of average yield of grain and *bhusa* and net returns per rupee investment of fertilizers. The data presented below are based on the average of two years yield.

TABLE 8

Economics of nitrogenous fertilizer application to wheat

Sources	Levels	Average yield Kg/ha		Additional return	Cost of nitrogen (Rs.)	Net return (Rs.)	Net returns per rupee investment
		Grain	Bhusa				
Urea	0	1096·68	2173·04				
	30	1784·82	3624·07	420·60	52·61	368·06	6·50
	60	2032·92	4583·25	596·34	105·22	491·12	4·67
Ammonium sulphate nitrate	0	1127·67	2028·11				
	30	1751·46	3751·51	401·93	56·61	345·32	6·10
	60	2287·95	3942·24	647·63	113·22	534·41	4·72
Ammonium sulphate	0	1107·17	2355·05				
	30	1749·37	3556·01	372·87	61·50	311·37	5·06
	60	2058·73	3803·15	605·97	123·00	482·97	3·92

It is clear from the table that urea and ammonium sulphate nitrate have given higher net returns than ammonium sulphate at both the levels of nitrogen. Although higher additional returns were obtained from 60 lb. nitrogen in all three fertilizers, yet the investment of a rupee on fertilizer for 30 lb. N dose is more productive than on the former. Earlier Gupta and Das (1962) have also found that the use of urea was more profitable than ammonium sulphate on wheat.

SUMMARY

Studies on the effect of different nitrogenous fertilizers at different concentrations in wheat indicate that:—

1. Application of nitrogen increased grain and *bhusa* yields with increasing concentrations. Developmental and growth characters were also similarly affected.
2. The response equations computed for grain and *bhusa* yields being quadratic, it was found financially profitable to increase the application of nitrogen upto 60 lb. N/acre.
3. Urea and ammonium sulphate nitrate gave higher financial net returns than ammonium sulphate and application of 30 lb. N./acre gave more profitable returns than 60 lb. per rupee investment.

REFERENCES

1. Anonymous, 1959. Fertilizers trial on wheat—*Report on experiments conducted from 1953 to 1956 under the Fertilizer Use Project, I. C. A. R.*
2. Agrawal, R. R. 1951. Summary of work done on manuring of crops in Uttar Pradesh, *Agriculture and Animal Husbandry, U. P. Sec.* III *Agri. Chem.*, 32-39.
3. Bajpai, M. R. 1951. Response of wheat to N, P, K. fertilizers. *Agric. and Animal Husbandry*, **1** (2) : 23-27.
4. Chandnani, J. J. 1954. Preliminary studies on the relative value of different forms of commercial nitrogenous fertilizers. *Indian J. Agric. Sci.*, **24** : 195-211.
5. Chandnani, J. J., Kavitkar, A. G. & Patel, A. S. 1960. Response curve on wheat. *Indian Soc. Soil. Sc.*, **8** (3) : 181-187.
6. Gautam, O. P. 1961. The effect of two sources of nitrogen at three levels each on growth and yield of wheat grown at two levels of irrigation. *Indian J. Agron.*, **6** (2) : 69-77.
7. Gupta, K. Sen & Dass, M. K. 1962. Wheat crop responds well to urea. *Fertilizer News*, **7** (7) : 11-13.
8. Mehrotra, C. L. 1963. *Pamphlet published by Bureau of Extension Education and Training, U. P., Lucknow.*
9. Mitra, A. K. 1955. Wheat manuring with ammonium sulphate and its economics in U. P. *Agric. & Animal Husbandry* **6** (4 & 5) : 20-23.
10. Relwani, L. L. 1960. The effect of ammonium sulphate and super phosphate in conjunction with farm yard manure on wheat yields. *Indian J. Agron.* **5** (i) : 22-31.
11. Vaidyanathan, M. 1933. Analysis of manurial experiments in India I, II, III, I.C.A.R.

STUDIES ON TRANSPLANTING OF VEGETABLE CROPS. IV. EFFECT OF AGE OF SEEDLING AND TIME OF TRANSPLANTING ON ONION (*ALLIUM CEPA* L.)

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In two previous experiments of this series 8 week old onion transplants were found to give the best results (3). For raising the seedlings in those experiments seed was sown in the nursery at one time and seedlings were transplanted when the required age was reached. Since the crop matured almost at the same time, the younger transplants remained for a comparatively shorter period in the nursery and for a longer period in the field in comparison to the older ones. The performance of such seedlings was, therefore, the result of the combined effect of two factors viz., their age as well as the time of their transplanting, though the latter was not one of the factors planned to be studied in those experiments. It was, therefore, thought desirable to examine further the effects of these two factors operating separately as well as together. The experiments reported in this paper included seedlings of various ages which were transplanted on different dates, necessitating thereby the sowing of seeds in the nursery on different dates.

Materials and Methods

In the first experiment onion seedlings of 4, 6, 8 and 10 weeks age were transplanted at each of the four transplanting dates beginning from Dec. 13, 1962 at an interval of 2 weeks. For supplying the seedlings of different ages for each transplanting seed of Patna Red variety was sown in the nursery seven times at fortnightly intervals from Oct. 4. There were, thus, 16 treatment combinations which were replicated 4 times in the field laid out according to the randomized block design.

In view of a very poor performance of 4 week old transplants, this age was excluded in the second experiment. On the other hand, since the highest yield was obtained from the first transplanting done on Dec. 13 it was thought desirable to include another transplanting to be done 2 weeks earlier. Therefore, in the second experiment there were three ages of seedling, i. e., 6, 8 and 10 weeks and four dates of transplanting, i.e., Dec. 1, 15, 29, 1963 and Jan. 12, 1964. There were, thus, twelve treatment combinations. The seeds were sown in the nursery 6 times at fortnightly intervals from Sept. 22, 1963 to supply the seedlings of different age groups.

Seedlings were transplanted 10 cm. from each other in lines 15 cm. apart in plots measuring 360 cm. × 300 cm. including a border of 30 cm. all around. Normal cultural operations were given to the crop throughout the period of their growth including manuring of the field at the rate of 250 kg. nitrogen per hectare. Half of the nitrogen was applied through compost two weeks before and the rest through ammonium sulphate at the time of transplanting.

The crop was harvested when most of the tops dried up.

RESULTS

Experiment I (1962-63)

The highest yield of 226·9 quintals bulbs per hectare was obtained when 10 week old seedlings were transplanted (Table 1). The yield was much reduced with each reduction of two weeks in age, and as a result, 4 week old transplants produced only about 37 per cent yield in comparison to the 10 week old ones. Though the age of seedlings did not affect the production of A grade bulbs significantly, B grade bulbs were considerably influenced by this factor. Here also the maximum percentage was contributed by 10 week old seedlings and as the age decreased, the percentage was gradually reduced. The position of C grade was just the reverse of that of B in this respect. Fresh weight of bulb and stand of the crop were both significantly affected by age, but the magnitude of variation was greater in the latter. When 10 week old seedlings were transplanted, 77 per cent could survive in the field as against only 62, 45 and 33 per cent in case of 8, 6 and 4 week old transplants respectively. The reduction in the stand of the crop was thus greater in the case of younger seedlings.

TABLE 1

Effect of age of seedlings on yield and growth characters in 1962-63.

Age of seedlings in weeks	Yield in q. per hect.	Per cent yield of different grades			Fresh wt. per bulb in gm.	Per cent stand of the crop	Height per plant in cm.	Number of leaves per plant	Fresh wt. of top per plant in gm.
		A (Diam. over 6 cm.)	B (Diam. between 4-6 cm.)	C (Diam. below 4 cm.)					
4	84·8	10·2	59·7	30·1	32·7	33·0	38·4	6·8	23·1
6	123·2	10·3	64·3	25·4	35·9	45·0	44·8	6·4	18 3
8	188·5	12·8	70·9	16·3	41·8	62·0	49·9	7·0	24·0
10	226·9	13·2	71·5	15·3	42·3	77·0	52·5	7·9	30·2
C. D. at 5%	21·10	Non-significant	6·60	6·71	4·82	3·3	...	...	...
C. D. at 1%	28·23		8·84	8·98	6·45	4·4	...	...	..

Since at the time of harvest the onion plants lost almost all the organs, viz., leaves, pseudostems etc., except the bulb, these characters were studied at their maximum development during the growth period to find out the effect of different treatments on them. An improvement in the height of the plant as well as the weight of the top to the extent of nearly 30 per cent was observed when the age was increased from 4 to 10 weeks. The number of leaves was also influenced similarly but the magnitude was smaller.

Time of transplanting greatly influenced the yield of onion crop. Delay in this operation had such an adverse effect that the subsequent transplantings produced only about 63, 42 and 24 per cent respectively of the highest yield obtained in the first planting done on Dec. 13 (Table 2). The quality of produce was also adversely affected by the delay in transplanting as was indicated by the reduction in larger (A grade) bulbs and increase in smaller (C grade) ones in the yield. As high as 19·1 per cent bulbs of the first transplanting were large enough to fall in A grade while in the last the percentage of such bulbs was only 2·4. On the other hand, C grade bulbs contributed only 16·8 per cent of the total yield obtained from the first transplanting, but this figure was more than double in the last one. The proportion of B grade bulbs was quite high in all the treatments. The average weight of bulbs from the first transplanting was 50·9 gm., while in the last one it was only about half as much. 80 per cent seedlings could survive the transplanting shock when they were set in the field on Dec. 13. Delay in transplanting had such an adverse effect on survival that almost 2/3 of the total plants of the last transplanting failed to establish themselves in the field. The vegetative growth of plants of the earlier transplantings, as indicated by the height, number of leaves and the weight of top, was also quite superior to that of later ones. The plants set earlier in the field matured earlier also.

TABLE 2

Effect of time of transplanting on yield and growth characters in 1962-63.

Time of transplanting	Yeild in q. per hect.	Per cent yield of different grades			Fresh wt. per bulb in gm.	Per cent stand of the crop	Height per plant in cm.	Number of leaves per plant	Fresh wt. of top per plant in gm.	Date of harvest
		A (Diam. over 6 cm.)	B (Diam. between 4-6 cm.)	C (Diam. below 4 cm.)						
Dec. 13	270·4	19·1	64·1	16·8	50·9	80·0	62·1	9·1	38·0	May 12
Dec. 27	169·3	15·7	66·5	17·8	42·7	57·0	47·9	7·5	19·0	May 22
Jan. 10	113·5	6·4	73·3	20·3	31·0	47·0	39·6	7·1	21·6	May 22
Jan. 24	65·4	2·4	62·0	35·6	26·5	35·0	42·8	7·1	17·1	May 30
C.D. at 5%	21·10	3·38	4·21	4·75	4·82	3·26	...	...	...	...
C.D. at 1%	28·23	4·52	5·63	6·35	6·45	4·36	...	...	...	...

The maximum yield of ripe onion bulbs was obtained when 10 week old seedlings were transplanted on Dec. 13 (Table 3). With reduction in age of seedlings as well as delay in their transplanting, the yield was gradually reduced. Increase in age of transplants had a beneficial effect on the fresh weight per bulb and the stand of the crop, but delay in setting the plants pulled down these characters markedly. The resultant effect of these two factors was so great that none of the youngest (four week old) seedings could survive when set in the field on the last date of transplanting (Jan. 24, 1963).

TABLE 3

Effect of interaction between age of seedlings and time of transplanting on yield, fresh weight of bulb and stand of the crop in 1962-63.

Treatments	Yield in q. per hect.	Fresh weight per bulb in gm.	Per cent stand of the crop
A_1 T_1	173·4	52·9	51·2
T_2	64·9	28·9	33·2
T_3	16·0	16·3	14·2
T_4	...	...	...
A_2 T_1	243·6	44·8	81·5
T_2	156·3	45·2	51·0
T_3	71·2	32·5	32·6
T_4	21·7	21·2	15·7
A_3 T_1	296·4	49·2	90·8
T_2	213·2	50·4	63·0
T_3	186·7	39·0	66·2
T_4	57·8	28·3	30·3
A_4 T_1	368·4	57·0	94·9
T_2	242·7	46·3	78·9
T_3	180·1	36·0	74·6
T_4	116·5	30·0	57·9
C.D. at 5%	42·17	9·64	6·52
C.D. at 1%	56·45	12·90	8·72

A_1, A_2, A_3, A_4=4, 6, 8 and 10 week old seedlings respectively.

T_1, T_2, T_3, T_4=Transplanted on Dec. 13 and 27, 1962 and Jan. 10 and 24, 1963 respectively.

Experiment II (1963-64)

In this experiment also, the performance of the crop in almost all cases improved with the increase in the age of seedlings from 6 to 10 weeks. Thus, in general, the best growth and yield were obtained in the case of 10 week old seedlings (Table 4). The age of seedlings had significant effect on the bolting of onion plants also. Under 6 weeks age group only 5·4 per cent plants produced flowering scapes. Every subsequent increase in age by 2 weeks nearly doubled this figure at each step.

TABLE 4

Effect of age of seedling on yield and growth characters

Age of seedlings in weeks	Yield in q. per hect.	Fresh wt. per bulb in gm.	Per cent stand of the crop	Height per plant in cm.	Number of leaves per plant	Fresh wt. of top per plant in gm.	Bolting percentage
6	200·7	49·6	85·0	50·5	7·1	18·9	5·4
8	205·8	52·4	89·4	55·4	7·5	21·6	10·3
10	237·9	53·0	89·2	61·7	8·9	30·8	21·1
C.D. at 5%	N. S.	N. S.	N. S.	...	...	...	6·94
C.D. at 1%				...	...	...	9·35

N. S.=Non-significant.

The effect of time of transplanting on all the characters was almost similar to that of the first experiment. The maximum yield was obtained by transplanting the seedlings on December 15 (Table 5). Both earlier and later transplantings lowered the yield. Bolting was also highly affected by the time of transplanting. As high as 36·6 per cent plants developed flowering shoots when transplanted on Dec. 1. Delaying the transplanting operation by only one fortnight reduced the magnitude of bolting to 12·1 per cent. There was practically no bolting when transplanting was delayed further. The earlier plantings were ready for harvest somewhat earlier.

TABLE 5

Effect of time of transplanting on yield and growth characters.

Time of trans-planting	Yield in q. per hect.	Fresh wt. per bulb in gm	Per cent stand of the crop	Height per plant in cm.	Number of leaves per plant	Fresh wt. of top per plant in gm.	Bolting percentage	Date of harvest
Dec. 1	240·7	65·3	76·2	45·4	8·7	37·6	36·6	May 15
Dec. 15	261·7	60·1	94·2	46·5	8·8	31·0	12·1	June 1
Dec. 29	192·1	48·2	95·2	42·3	7·3	15·1	0·3	June 1
Jan. 12	147·2	34·2	85·9	41·3	6·7	11·1	0·0	June 2
C.D. at 5%	25·64	6·53	6·72	...	...	...	5·92	...
C.D. at 1%	34·54	8·75	9·05	...	...	...	7·97	...

The interaction between age of seedling and the time of transplanting produced no significant effect on any of the characters except bolting. As high as 60 per cent bolting was found in the case of 10 week old seedlings transplanted on Dec. 1 as against 33 and 17 per cent in the case of 8 and 6 week old ones respectively transplanted on the same date (Fig. 1). The bolting decreased sharply in all cases when the transplanting was done a fortnight later. There was practically no bolting when the operation was delayed by another fortnight.

DISCUSSION

The yield of onion depends on the weight of individual bulbs as well as the population of plants per unit area. Both these factors were favourably influenced by an increase in the age of transplants tried in these experiments. The beneficial effect of increased age of seedlings on stand was also observed by Singh *et al* (5) in the case of cauliflower. Thus the total yield of onion went on improving with an increase in age of transplants upto 10 weeks. Patil *et al* (4) found that when transplanting age of Nasik Red onion was increased by 1 week periods from 7 to 14 weeks, there was a progressive increase in yield. The four week old onion seedlings maintained a very poor stand due to high mortality. Lloyd (2) stated that a very young and tender plant of a readily transplantable species had insufficient substance to withstand the vicissitudes of weather and was much less likely to thrive than somewhat older plants of the same species.

The average weight of individual bulbs was higher in earlier transplantings in both the experiments. According to Thompson and Kelley (6) bulbing in onion is controlled by photoperiod and temperature. The plants begin to form bulbs at about the same time, regardless of the time they were planted. Leaf initiation ceases when bulbing starts and the growth of the bulb depends on the leaves already present when bulbing commences. In the present experiments, early transplanting permitted the plants to stay for a longer period in the field where the growth factors were much more favourable than those in the nursery, thus helping them to make more vegetative growth before the commencement of bulbing than those transplanted later. This resulted in the production of bigger bulbs by the plants of earlier plantings.

A high percentage of plants produced flowering scapes when older seedlings were transplanted earlier in the season. Similar results were reported by Patil *et al* (4) from Poona. Clarke *et al* (1) also found that earlier transplantings produced greater number of bolts.

The highest yield of bulbs per hectare was obtained when the seedlings were transplanted in the middle of December because it offered the best compromise between the two factors of weight per bulb and stand of the crop. Transplanting earlier than this would also not be desirable from the point of view of bolting. Since it would not be advisable to sow onion seed in the nursery earlier than the first week of October due to the risk of late rains in this region, it would naturally mean that the seedlings would be about 10 weeks old, which were found to give the best results in these experiments. It is not surprising that in an earlier paper of this series (3) eight week old transplants gave the best results since onion seeds were sown after the middle of October in those experiments and the performance of the plants was the result of the combined effect of age of seedlings and time of transplanting.

SUMMARY

The results of two experiments conducted to study the effect of age of seedlings and their time of transplanting on the performance of onion crop are reported in this paper.

The yield per hectare was maximum when 10 week old transplants were used. The growth of the plants was also the best in this case. With decrease in age there was a general reduction both in yield and growth characters.

The highest yield was obtained by transplanting the seedlings around mid December. Both early and late transplantings gradually decreased the yield. Height of plants and number of leaves were also affected in the same way. Though the fresh weight of bulb and the top was the best in plants set in the beginning of December, a poorer stand of the crop prevented this planting from becoming the highest yielder. Plants of earlier transplantings were found to mature somewhat earlier, but such plants produced higher percentage of bolt ing also which is an undesirable character.

60 per cent of the onion plants produced bolting when 10 week old seedlings were transplanted on Dec. 1. Reduction in age of transplants as well as delay in transplanting reduced bolting markedly and there was practically no bolting when transplanting was done towards the end of December or later.

CONCLUSION

The findings of these experiments have shown that under the conditions of Agra region 10 week old onion seedlings should be transplanted in the middle of December to get the best results.

LITERATURE CITED

1. Clarke, A. E.; Pollard, L H. & Howthorn, L. R. 1952. Effect of time of seeding on the winter survival and subsequent seed stalk development of onions. *Proc. Amer. Soc. hort. Sci.*, **59** : 439-44.
2. Lloyd, J. W. 1942. Productive Vegetable Growing. J. B. Lippincott Co., Philadelphia. p. 49.
3. Maiti, R.G.; Singh, S. M. Mansa Ram, & Singh, R. P. 1964. Studies on transplanting of vegetable crops. III. Effect of age and pruning of transplants on onion (*Allium cepa* L.). *B. V. J. Agri. Sci. Res.* **6** (1 & 2) : 8-13.
4. Patil, J. A.; Waghmare, D. R. & Patil, A. K. 1958. Age of seedlings in onion as a rabi crop. *Poona Agric. Coll. Mag.*, **49** : 83-6.
5. Singh, A. R.; Jain, P. C. & Singh, S. M. 1960. Studies on transplanting of vegetable crops. I. Effect of age and number of seedlings with and without starter solution and hardening on cauliflower. *Indian J. Hort.*, **17** (3-4) : 217-24.
6. Thompson, H. C. & Kelly, W. C. 1957. Vegetable Crops. McGraw-Hill Book Co., New York. p. 355.

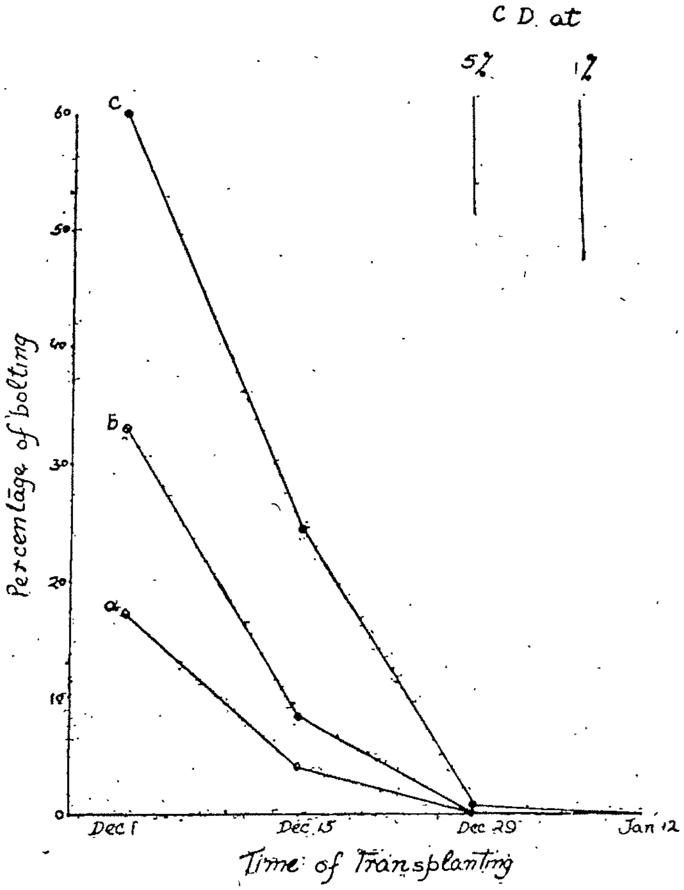

Fig 1 Effect of interaction between age of seedling and time of transplanting on bolting of onion plants.

a, b, c = 6, 8 and 10 week old transplants respectively

THE ECONOMICS OF FERTILIZER—A CASE STUDY

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Of late, the use of fertilizers is becoming more popular with the Indian cultivators as a result of the top priority given to the development of agriculture, particularly in the sphere of food production. The departments of agriculture have made certain recommendations in respect of the amount of fertilizers to be applied to individual crops. But it is not enough to tell the cultivator about the yield level per hectare in physical terms. It is also very important to apprise him of the net profit in terms of rupees which he can expect from the use of a given dose of fertilizer.

Under the diminishing returns, it is profitable to increase the level of production as long as the added return is greater than the added cost. The cultivator should stop the application of fertilizer where the last rupee spent on it just pays for itself.

The following fertilizer experiment was conducted on a cultivator's field by the Agricultural Economics Section of the Govt. Agricultural College, Kanpur with the following objectives:—

(i) To determine the most economic level of the use of fertilizer.

(ii) To show the demonstrative effect of the different doses of fertilizer in terms of physical performance.

The whole experiment was conducted under the supervision of the Sectional staff. The fertilizer in the form of ammonium sulphate was given free of cost to the cultivator and the staff along with the farm family harvested, threshed and weighed the yield to get the highest degree of accuracy in relation to the yield data.

Details of the Experiment

Name of the crop—Wheat K_{13}

Location of the Experiment—Village—Rampur Bhimsen.

Experimental design—Randomised Block.

Treatments

In pounds per acre (1964-65)

N_0	N_1	N_2	N_3	N_4	N_5
Control	15	30	45	60	75

25 lbs of P_2O_5 (in the form of superphosphate) per acre was applied as basal dressing in furrows in the whole experimental field. The crop was sown

on November 2, 1964 and harvested in April, 1965. The first irrigation was given on November 30, 1964 and the second on January, 27, 1965.

Empirical Results

It will be seen from Table I that the application of nitrogen upto the level of 45 lbs. per acre increases the yield of wheat grain. Significant differences in grain yields, were, however, observed only in the case of 30 lbs. and 45 lbs. nitrogen per acre. The application of nitrogen over 45 lbs. per acre resulted in the reduction of grain yield. The yield of bhusa, however, increased with the increase in the amount of nitrogen applied.

Economic Analysis

Quadratic function was fitted to the data

$$Y = a + bx + cx^2$$

Grain $Y = 10{\cdot}4034 + 0{\cdot}064868x - 0{\cdot}0003648x^2$

Bhusa $Y = 21{\cdot}1822 + 0{\cdot}01601x - 0{\cdot}000688x^2$

The observed and expected values of the grain and bhusa are given in Table 2 which shows that the observed yield of grain increases upto the application of 45 lbs of nitrogen per acre. In respect of the expected values, the decline in yield starts after the application of 40 lbs. of nitrogen per acre. This behaviour gives some indication that the application of nitrogen over 40 lbs per acre may not be useful.

Most profitable rate of Application

The concept of added cost and added return or marginal cost and marginal revenue has been used to determine the most profitable rate of application of nitrogen per acre

$$P_y \Delta Y = P_x \ \Delta X$$

It will be seen in Table 3 that 40 lbs of N per acre gives the highest net economic returns per acre. The prices of wheat and bhusa were calculated @ Rs. 52·50 and Rs. 9·38 per quintal respectively. The cost of nitrogen was Re. 0·90 per pound.

CONCLUSION

The fertilizer trial study shows that the maximum economic returns from wheat and bhusa are obtained by the application of 42 lbs of nitrogen per acre where the marginal cost of Rs. 4·50 is almost equal to the marginal revenue for grain and bhusa combined.

Such types of fertilizer trial studies should be conducted on a wider scale to give definite recommendation in the economic use of fertilizers, as the cultivators are now more interested in money returns on their investments.

TABLE 1

Yield of Wheat grain and bhusa per plot.

Plot Number	Yield in Kgms.						Plot Size=0·014					
	Control		N_{15}		N_{30}		N_{45}		N_{60}		N_{75}	
	Grain	Bhusa	Grain	Bhusa	Grain	Bhusa	Grain	Bhusa	Grain	Bhusa	Grain	Bhusa
1	14·5	28·5	15·9	31·0	16·6	37·6	17·1	37·2	13·0	43·0	14·9	41·6
2	14·8	28·5	15·5	35·0	15·3	35·5	17·2	40·2	16·6	41·5	14·8	44·8
3	15·5	32·3	14·9	34·8	15·8	33·0	17·5	35·5	14·1	30·3	14·2	36·0
4	14·5	29·1	14·8	29·9	15·1	34·1	17·4	37·0	16·8	38·5	14·5	38·2
Total	59·3	118·4	61·1	130·7	62·8	140·2	69·2	149·9	60·5	153·3	58·4	160·6
Average yield per plot in kgms.	14·83	29·60	15·28	32·68	15·70	35·05	17·3	37·48	15·13	38·33	14·60	40·15
Average yield per acre in Quintals	10·593	21·142	10·914	23·343	11·214	25·036	12·357	26·771	10·807	27·379	10·429	28·679
Average yield per hectare in Quintals	26·165	52·221	26·958	57·657	27·699	61·839	30·522	66·124	26·693	67·626	25·760	70·837

C.D. for wheat grain=1·236 C.D. for bhusa=1·905

TABLE 2

Observed and Expected values of Wheat Grain and Bhusa in Quintals per acre.

Sl. No.	Treatments	Wheat Grain		Bhusa	
		Observed value	Expected value	Observed value	Expected value
1.	N0	10·593	10·4034	21·142	21·1822
2.	N5	...	10·7061	...	21·9155
3.	N10	...	10·9656	...	22·6144
4.	N15	10·914	11·1818	23·343	23·2789
5.	N20	...	11·3548	...	23·9090
6.	N25	...	11·4846	...	24·5047
7.	N30	11·214	11·5711	25·036	25·0660
8.	N35	...	11·61440	...	25·5929
9.	N40	...	11·61444	...	26·0854
10.	N45	12·357	11·5712	26·771	26·5435
11.	N50	...	11·4848	...	26·9672
12.	N55	...	11·3551	...	27·3565
13.	N60	10·807	11·0220	27·379	27·7114
14.	N65	...	10·9295	...	28·0319
15.	N70	...	10·8320	...	28·3180
16.	N75	10·429	10·7302	28·679	28·5697

TABLE 3

Marginal cost and marginal return to nitrogen on irrigated wheat at the village Bhimsen, Kanpur.

Nitrogen (X) applied per acre in lbs.	(Change in X) in lbs.	Y (mean yields) in quintals		dy (change in yield) in kgs.		Marginal Revenue in Rs.		Total	PX (Marginal cost in Rs.)
		YG (Grain)	YB (Bhusa)	dYG	dYB	dYG×PYG	dYB×PYB		
0	5	10·4034	21·1822	...	...	...	...	...	...
5	5	10·7061	21·9155	30·27	73·33	15·60	6·88	22·50	4·50
10	5	10·9656	22·6144	25·95	69·89	13·62	6·56	20·18	4·50
15	5	11·1818	23·2789	21·62	66·45	11·35	6·23	17·58	4·50
20	5	11·3548	23·9090	17·30	63·01	9·08	5·91	14·99	4·50
25	5	11·4846	24·5047	12·98	59·57	6·81	5·59	12·40	4·50
30	5	11·5711	25·0660	8·65	56·13	4·54	5·26	9·80	4·50
35	5	11·61440	25·5929	4·33	52·69	2·27	4·94	7·21	4·50
40	5	11·61444	26·0854	0·004	49·25	0·02	4·62	4·64	4·50
45	5	11·5712	26·5435	— 4·32	45·81	—2·27	4·30	— 2·03	4·50
50	5	11·4848	26·9672	— 8·64	42·37	—4·54	3·97	— 0·57	4·50
55	5	11·3551	27·3565	—12·97	38·93	— 6·81	3·65	— 3·16	4·50
60	5	11·1822	27·7114	—17·29	35·49	— 9·08	3·33	— 5·75	4·50
65	5	10·9660	28·0319	—21·62	32·05	—11·35	3·01	— 8·34	4·50
70	5	10·7066	28·3180	—25·94	28·61	—13·62	2·68	—10·94	4·50
75	5	10·4040	28·5697	—30·26	25·17	—15·89	2.36	—13·53	4·50

*PYG (Price of wheat grain per quintal)=Rs. 52·50
*PYB (Price of Bhusa per quintal) =Rs. 9·38
* PX (Cost of 5 lbs. of nitrogen) =Rs. 4·50

MOUTHPARTS AND THE FEEDING MECHANISM IN *MELANAGROMYZA OBTUSA* (MALLOCH) (AGROMYZIDAE: DIPTERA)*

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INTRODUCTION

The mouthparts or the proboscis of Diptera attracted the attention of morphologists from very early days. Major works on the topic are by Suffolk, (1869), McClosakie (1880 & 1884), Wesche (1908), Cragg (1912), Peterson (1916), Whitefield (1925), Jobling (1926 & 1928), Graham-Smith (1930), Snodgrass (1944), Bletchley (1952, 1954 & 1955) and Nayar (1964). Of these, the works of Wesche and Graham-Smith both on the mouth parts of blow flies, Snodgrass on the feeding apparatus of biting and sucking insects are of outstanding nature. The present paper is one in a series on the detailed morphological studies on the *Melanagromyza obtusa* (Malloch), a serious pest of *Cajanus indicus* L.

MATERIAL AND METHODS

Flies available during the months of February, March and April were collected and kept in dilute KOH solution (5%) overnight. The alkaline effect of the KOH was neutralised by washing them in glacial acetic acid. Stained and unstained permanent mounts were prepared in Canada balsam. Microtome sections of Bouin's fixed material were cut for anatomical details. Dissections of the fresh and Alcoholic Bouin's fixed flies embedded in wax trays were helpful in the study of musculature. Diagrams were made with the help of Camera lucida and Prism eye piece.

OBSERVATIONS

Proboscis—(Figs. 1—10) The pendulous proboscis hanging down from the rim of the subcranial fossa (oral fossa of other Dipteran morphologists) is retractable into the subcranial cavity. It is easily divisible into three regions:—

(1)	the basiproboscis or rostrum or oral cone	(BP)
(2)	the mediproboscis or haustellum	(MP)
(3)	the distiproboscis or labella.	(DP)

In the retracted condition the labellar portion is folded back on to the postero-lateral surface of the distal end of the haustellar region. These two regions are further folded up against the anterior surface of the basiproboscis and then the whole structure is withdrawn into the subcranial cavity, the tip of the labella nicely plugging the so-called "oral aperture" or "proboscis aperture" (Jobling, 1926) or the "subcranial fossa" (Crampton, 1942).

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Basiproboscis (Figs. 1 & 2) is the longest, thickest and the conical portion of the proboscis, the proximal margin of it being attached to the "oral margin" by the periclypeal membrane (Fig. 1, PCLM). This periclypeal membrane is believed to represent the widened out epicranial sulcus of the lower groups of insects. The sclerotised horse-shoe shaped clypeus (Fig. 1, CLY) forms the anterior surface while posteriorly it is completely membranous. The lateral sides of the basiproboscis are supported internally by the inflections of the clypeus, forming the lateral plates or the lateral walls of the cibarial pump. Distally, the arms of the clypeus are acutely pointed and the area between them is membranous, which is continuous with the labrum-epipharynx (Fig. 1, LEP).

The clypeus was first recognised by Patton and Cragg (1912). Graham-Smith (1930) calls it the "anterior arch of the fulcrum". Most of the recent Dipterists followed Paterson (1916) in calling this "torma" with the mistaken notion that it is derived from the lateral basal process of the labrum. Crampton (1942) is of the view that this sclerite is "formed by the distinct anteclypeal sclerites" such as those found in termites, mole crickets and other Orthopteroid insects. Snodgrass (1909), Ferris (1950) and Nayar (1963), however, consider it as clypeus due to the attachment of the cibarial dilators (Figs. 7 & 8, 1) on its posterior surface.

Internally, the basiproboscis exhibits a complex structure which contains the food canal forming the so-called "cibarial pump" or "fulcral pump" of Crampton (1942). The cibarial pump is a stirrup-shaped organ with the clypeus forming the anterior portion of the stirrup rim. The lateral portions of the rim are constituted by the lateral plates. The posterior margins of the lateral plates are fused to the cibarial plates (Figs. 7 & 8, VCBP and DCBP), which form the posterior portion of the stirrup. The cibarial plates actually seem to be derived from the intima of the pharyngeal region. Due to the fusion laterally of their free margins, these plates enclose an antero-posteriorly depressed cavity, the cibarial cavity (Fig. 7, CFC), which communicates proximally with the oesophagus (Fig. 7, OES) and distally with the pre-pharyngeal food canal (Fig. 7, PRPEC). Anteriorly these plates are concave while posteriorly convex. Medially, along the anterior surface of the anterior plate, there is a distinct ridge (Fig. 8, RD), which provides surface for the attachment of the cibarial dilators the contraction of which dilates the cibarial cavity. Distally, the ventral plate of the cibarium is produced into a cornua which articulates with the proximal margin of the hypopharynx (Fig. 7, HYP).

The cibarium and the associated structures are often referred to as "fulcrum" by Dipterists because the whole structure swings forward and backward with the protraction and the retraction of the proboscis, the hinging portion being the periclypeal membrane. Some people refer to this structure as the "pharyngeal skeleton" and Crampton (1942) calls it as the "fulcral pump". Peterson (1916) considers that the distal region of the fulcrum is formed by the basal portions of the epipharynx and hypopharynx while its proximal portion is formed by the torma. Bletchley (1954) reports a fulcrum where the lateral plates are completely absent in *Empis livida* L. (Empididae: Diptera) (Figs. 7, 11 & 12, SDT).

The salivary duct passes downwards through the cavity enclosed by the cibarial pump and the posterior membranous wall of the basiproboscis. Just before entering the hypopharynx it becomes slightly bulbous to form the salivary pump (Fig. 7, SLP) or syringe operated by muscles.

In the membranous lateral sides of the basiproboscis are seen inserted the clavate, elongated, setaceous, sclerotised lobes (Figs. 1, 2, & 4, MXP). These represent the maxillary palpi and are covered with numerous setae along their inner surfaces. Sections passing through it reveal that it is richly supplied with sensory cells which innervate the sensory setae.

Wesche (1908) considers these palpi as labial palpi but Peterson (1916) by his studies on the head capsule and mouth parts proved them to be maxillary palpi. The rod-like apodemes of the labrum-epipharynx (Figs. 1 & 11, LEPAP) also act as lateral scaffoldings for the membranous basiproboscis. These are often mistaken to be the maxillary sclerites, supporting the maxillary palpi, which are missing in *Melanagromyza obtusa.*

Mediproboscis, (Figs. 1 & 2, MP) the more or less cylindrical intermediate region, considered by Snodgrass (1909) as representing the true proboscis of other insects, forms almost one-third of the whole length of proboscis in *Melanagromyza obtusa.* According to Crampton (1942), this portion wholly belongs to the labium and includes the prementum posteriorly, while anteriorly it bears the labial gutter (Figs. 7, 9 & 10, LBG) or the 'trough' in which is lodged the hypopharynx, the labrum-epipharynx acting as its roof. The haustellar region is slightly narrower towards the distal end and bears the third portion, the distiproboscis (Figs. 1, 2 & 7, DP) or the labella.

The labial or the posterior portion of the haustellum is formed by the heavily sclerotised prementum often called by Dipterists as "theca" (Figs. 2, 7, 9 & 10, TH), though Hendel (1928) uses the same term for the hyoid sclerite. Crampton (1942) prefers prementum to theca as the latter is used to convey different meanings in different insects. Dorsally it forms a depression or gutter, the labial gutter, to accommodate the hypopharynx. The ventral wall is well chitinised while dorsally the chitinisation is weak. Distally, the labial gutter communicates with the prestomal space (Figs. 1, 3 & 7, PRS) in the labella, into which opens the prepharyngeal food canal and the radiating pseudotracheae (Figs. 3, 7 PST).

The boat-shaped hypopharynx forms the floor of the prepharyngeal food canal ("pre-oral food canal" Nayar, 1963) and is traversed longitudinally by the salivary canal (Fig 9, SLC). The salivary duct enters the hypopharynx at its proximal end, finally opening in a transverse slit (Fig. 11, SLCO) situated subapically on the anterior face. Labrum-epipharynx, which forms the roof of the prepharyngeal food canal, is broader basally and tapers gradually towards the apex. Its anterior face, representing the labrum, is convex and the epipharyngeal posterior face is longitudinally concave to form the roof of the prepharyngeal food canal. It seems to be more appropriate to consider the distal opening of the cibarial pump, proximal to the labrum-epipharyngeal-hypopharynx complex, as the true oral opening (Fig. 7, OO) because of the complete absence of any tubular nature thereafter. Graham-Smith (1930) is non-committal in designating the true mouth opening but refers to this canal as the "prepharyngeal food canal". According to Hendel (1928) the sides of the food canal formed by the labrum and the hypopharynx are closed by a short galea in lower Diptera. Such a condition, however, has not been reported so far by any other worker in higher Diptera. In view of this fact the aperture in the middle of the labellar lobes, with which the prepharyngeal food canal communicates terminally, should be called as pre-oral aperture or "prestomum" (Fig. 7, PRS) described by Snodgrass (1909), and unlike the "oral aperture" of Hewitt (1914).

Distiproboscis (Figs. 1, 2, 3 & 7, DP) is purely labial in constitution. It comprises a pair of soft, oval, membranous lobes which bear the so-called 'oral uckers'. The ventral or the distal surface of the lobes are traversed by radiatng cuticular grooves, the "psuedotracheae" (Fig. 3, 7, ST) which serve as food conductors. At the time of feeding, the labellar lobes are spread out to form a flat disc which is applied against the food surface. The two lobes are separaed from each other by a deep cleft anteriorly upto the prestomum. Posteriorly, he two lobes are connected by an inter-labellar membrane (Fig. 2, ILM). The abellar lobes are beset with numerous prominent sensory bristles (Fig. 2, SP) posteriorly.

The psuedotracheae are open canals whose non-collapsible condition is maintained by a sort of rib-like thickenings or psuedo-ctinidia (Fig. 5, PSTN). The semi-loops of the pseudo-ctinidia are forked at one end and broadened at he other. These form a sort of filtering mechanism at the time of the food ntake. There are twelve such canaliculae or pseudo-tracheae in each labellar obe opening directly or indirectly into the prestomum. On either lobe, the nterior most two canaliculae form an anterior collecting channel (Fig. 3, ANCC), opening into the prestomum; the next two opening directly into he prestomum while the rest of them first empty into the posterior collecting hannel (Fig 3, PNCC), which in its turn opens into the prestomum. Almost similar condition is reported by Graham-Smith (1930) in blow-fly and Nayar 1963) in *Syrphus balteatus*, although the number of the canaliculae differ. On ither lateral sides of the prestomum, there are present a pair of spinous processes, he prestomal spines (Fig. 3, PSS) which help in piercing the plant tissue at the ime of feeding. These correspond to the "prestomal teeth" or "oral teeth", characteristic feature of many blood-sucking muscoid flies like *Musca crassirostris*.

Two sclerotised supporting bars, the labellar sclerites (Fig. 2, LBS) ("furca" of Graham-Smith, (1930) and Nayar (1963), "discal sclerites" of other Dipterists), seen one on either lobes of the labella, extend from near the vicinity of prestomum to the postero-lateral periphery of each lobe. An arched sclerotised bar (Fig. 2 AB) connects the two labellar sclerites at their median ends. This bar has been referred to as "central process' by Graham-Smith (1930) and Nayar (1963), and constitutes internally the posterior semi-circle of the prestomum. The labellar sclerites articulate with the distal pointed free end of the theca and aid in the extension of the labellar lobes. Graham-Smith (1930) reports a pair of chitinised rods, "paraphyses", in the haustellar region on either side of the hypopharynx, to which are attached the furcal apodemes or the labellar sclerites. But in *Melanagromyza obtusa* (Malloch) no such structure is present.

Musculature—The musculature of the proboscis consists of eight intrinsic and four extrinsic muscles.

Intrinsic Muscles

(*i*) *Pharyngeal dilators* (Figs. 7, 8 & 13; 1) are well developed muscles responsible for the suction of the food. They originate on the antero-lateral wall of the clypeus and are attached to the median ridge on the dorsal cibarial plate. The contraction of these muscles increases the lumen of the cibarium thereby effecting the suction.

(*ii*) *Dilators of the labrum-epipharynx* (Figs. 13 & 14; 2) originate on the anterior wall of the labrum and become inserted on the epipharynx posteriorly. The contraction of these muscles increase the posterior concavity of the labrum-epipharynx by lifting the epipharyngeal wall.

(*iii*) *Flexor of the labrum-epipharynx* (Fig. 13; 3) are long slender muscles extending from the ventral margin of the clypeus to the proximal margin of the labrum-epipharynx. The contraction of these muscles flexes the labrum-epipharynx on the mediproboscis.

(*iv*) *Extensor of the haustellum* (Fig. 13; 5). These are short muscles arising from the distal end of the ciarium and attached to the apodeme of the labrum-epipharynx. The contraction of these muscles aids in the straightening of the haustellum.

(*v*) *Dilators of the labial gutter* (Figs. 13 & 15; 6) arise on the heavily sclerotised theca and become inserted on the inner wall of the labial gutter. The contraction of these muscles increases the depth of the labial gutter to enable the passage of the food.

(*vi*) *Extensor of the labella* (Fig. 13; 7) is a strong muscle which originates from the proximal margin of the thecal sclerite and is inserted on the anterior end of the furca (labellar sclerite), the contraction of which helps in extending the labellar lobes.

(*vii*) *Retractor of the labella* (Fig. 13; 8), originates on the posterior median region of the theca and is attached on the labellar sclerites posterior to the insertion of the labellar extensors. The contraction of this muscle retracts the labellar lobes.

(*viii*) *Regulators of the salivary pump* (Fig. 13; 12) are long poorly developed muscles which arise from the proximal cornua of the fulcrum and get inserted on the enlarged salivary pump in the distal region of the mediproboscis. The contraction of these muscles regulates the flow of the salivary secretion into the hypopharynx.

Extrinsic Muscles

(*i*) *Retractors of fulcrum* (Fig. 13; 4) are extremely well developed muscles originating on the prefrons immediately above the subcranial fossa and becoming inserted on the proximal cornua of the fulcral pump. The action of these muscles is to bring the basiproboscis in a horizontal position (plane).

(*ii*) *Retractors of the basiproboscis* (Fig. 13 ; 9) are very strong muscles which after arising from the postero-lateral wall of the cranium above the occipital foramen, get inserted on the distal posterior wall of the basiproboscis. The contraction of these muscles retracts the basiproboscis into the subcranial fossa.

(*iii*) *First accessory retractor of the basiproboscis* (Fig. 13; 10). These originate from the corpotentorium and are inserted on the distal posterior wall of the basiproboscis proximal to the place of insertion of the basiproboscis. These assist in the retraction of the basiproboscis.

(*iv*) *Second accessory retractors of the basiproboscis* (Fig. 13; 11) are rather poorly developed muscles. After originating on the cranial wall inner to the anterior tentorial pits, they become inserted on the posterior wall of the basiproboscis slightly proximal to the insertion of the first accessory retractors. The contraction of these muscles suppliments the functions of the basiproboscis retractors and the first accessory retractors.

MECHANISM OF FEEDING

The adult *Melanagromyza obtusa* feeds mainly on plant juice but in the laboratory they were fed on sugar solution and honey. In the normal process of feeding a puncture is made on the soft parts of the stem, leaves or the flower (usually on the calyx) with the help of the prestomal teeth (Fig. 3, PSS) of the protruding proboscis. This results in the exudation of the plant juice and the under surface of the proboscis (the pseudotracheal surface) is applied closely on to the wound. The sucking-in of the fluid, oozing out through the wound of the plant tissue, is effected by the contraction of the cibarial dilators (Fig. 7 & 13; 1), which results in the distension of the cibarial food canal. This creates a near vacuum condition in the cibarial food canal resulting in the sucking-in of the plant juice through the pseudotracheae and the prestomum into the pre-pharyngeal food canal. The pseudo-ctinidiae (Fig. 5, PSTN) prevents the collapsing of the pseudotracheae.

Feeding on solid food, as reported by Nayar (1963) in the case of *Syrphus balteatus*, where it feeds on the pollen, is not observed in this fly. The adult flies are frequent visitors of flowers but they are seen feeding on the calyx and never on the pollen. This is further confirmed as no trace of pollen or solid food was found in any portion of the digestive tract.

SUMMARY

The proboscis of *Melanagromyza obtusa* Malloch is attached to the subcranial fossa and is divisible into a basiproboscis, a mediproboscis and a distiproboscis. The anterior and the lateral sides of the basiproboscis are strengthened by the clypeus and the lateral plates of the clypeus. The ventral side of the mediproboscis is supported by the theca while the labrum-epipharynx forms the dorsal side. Distiproboscis is membranous with twelve pairs of pseudotracheae opening into the prestomum.

A pair of prestomal spines in the prestomum are helpful in the piercing of the plant tissue. The two labellar lobes are connected by an interlabellar membrane. The boat-shaped hypopharynx is traversed by the salivary canal. The wall of the pharynx is chitinised, forming the anterior and the posterior cibarial plates. The cibarial dilator muscles are attached to the anterior cibarial plate. The mouth opening is seen at the anterior extremity of the cibarium at the base of the hypopharynx. There are twelve sets of muscles associated with the functioning of the proboscis, of which, the pharyngeal dilators and the retractors of the fulcrum are comparatively better developed.

ACKNOWLEDGEMENTS

The author wishes to express his deep felt gratitude to Dr. Santokh Singh for guidance and help. He is grateful to Dr. T. Singh, Professor of Zoology and Entomology, and the Rev. P. T. Chandi, Principal, St. John's Collge, Agra, for their manifold help during the course of this work. His thanks are also due to Dr. David Livingstone of the Zoology Department and to the Research Scholars of the School of Entomology for their help. He is also grateful to the Ministry of Education, Government of India and to the Scientific Research Committee of U.P. Government for financial assistance.

REFERENCES

1. Bletchly, J. D. 1954. The mouth parts of the dance fly, *Empis livida* L. (Diptera: Empididae). *Proc. Zool. Soc. Lond.*, **124** (2) : 317-334.
2. Cragg, F. W. 1912. Studies on the mouth parts and the sucking apparatus in the blood Sucking Diptera. No. 1. *Philaematomyia insignis* Austen. *Sci Mem. Med. Ind.*, Calcutta, **54** : 1-15.
3. Crampton, G. C. 1942. The Diptera or True Flies of Connecticut. *Conn. Geol. Nat. Hist. Survey*, Bulletin No. **64** : 10-165.
4. Ferris, G. F. 1950. External morphology of *Drosophila* given in the *Biology of Drosophila*. John Willey & Sons N. Y., Chapman and Hall Ltd., London.
5. Graham-Smith, G. S. S. 1930. Further observations on the anatomy and function of the proboscis of the blow fly etc. *Parasitology*, **22** : 47-115.

5. Hendel, F. 1918. Zeifluegler oder Diptera, II; Allgo meiner Teil. *Dide Tierwelt Deutschlands*, **2** : 1-135.

7. Hewitt, C. G. 1914. The house fly. *Gambridge Univ. Press.*

3. Jobling, B. 1926. A comparative study of the structure of the head and mouth parts in *Hippoboscidae* (Diptera : Pupipara). *Parasitology*, **8** (3) : 320-348.

)\. Jobling, B. 1928. The structure of the mouth parts in Nycteribiidae (Diptera : Pupipara). *Parasitology*, **10** (3) : 254-272.

0. Mc Closkie, G. 1880. The proboscis of the House fly. *Ann. Nat.*, **14** : 153-161.

1. Mc Closkie, G. 1884. Kreepelin's proboscis of *Musca. Ann. Nat.*, **18** : 1234-1244.

2. Miller, A. 1950. The internal anatomy and histology of the imago of *Drosophila melanogaster* in "Biology of *Drosophila*". John Willey & Sons N. Y., **6** : 420-434.

3. Nayar, J. L. 1963. Morphology of the Hover-fly *Syrphus balteatus* (De Geer) (Syrphidae: Cyclorrhapha : Diptera). Agra University Ph. D. thesis (Unpublished).

4. Patton, W. S. and F. W. Cragg. 1913. A text book of medical Entomology. Published br Christian Literary Society for India, Calcutta. 1-76..

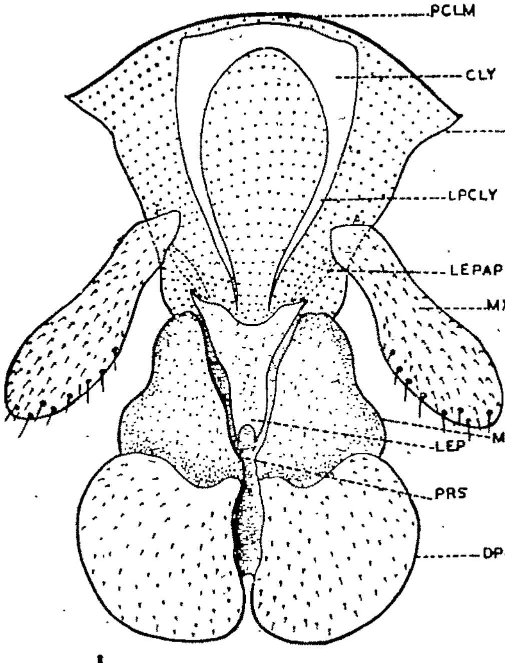
5. Peterson, A. 1916. The head capsule and Mouth parts of Diptera. *Illinois Biol. Manographs*, **3** (2) : 1-112

6. Snodgrass, R. E. 1944. The feeding apparatus of biting and sucking insects affecting man and animals. Smithsonian Miscell. Coll., **104** (7) : 113.

7. Suffolk, W. T. 1869. On the Proboscis of Blow-fly. *Monthly Microsc., Journ.*, **1** : 331-342.

8. Wesche, W. 1908. The proboscis of blow-fly *Calliphora erythrocephala* Mg. *London J. Queckett Micr. Club.*, **2** (10) : 283-294.

9. Whitfield, F. GH. 1925. The relation between the feeding habit and the structure of mouth parts in Asilidae. *Proc. Zool. Soc., London*, **5** : 599-638.



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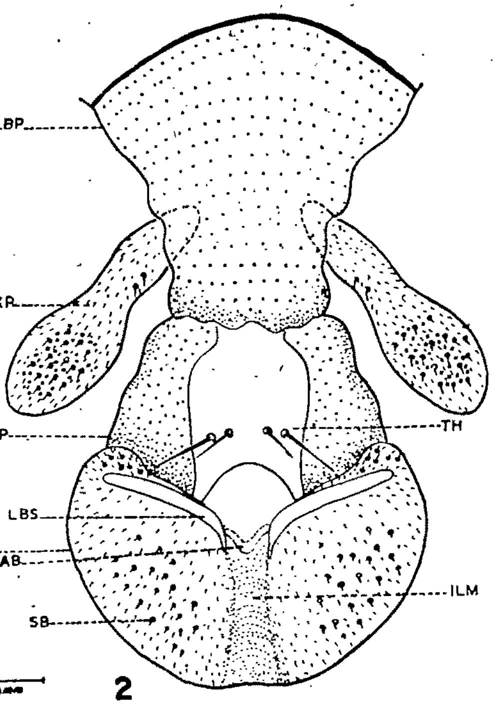

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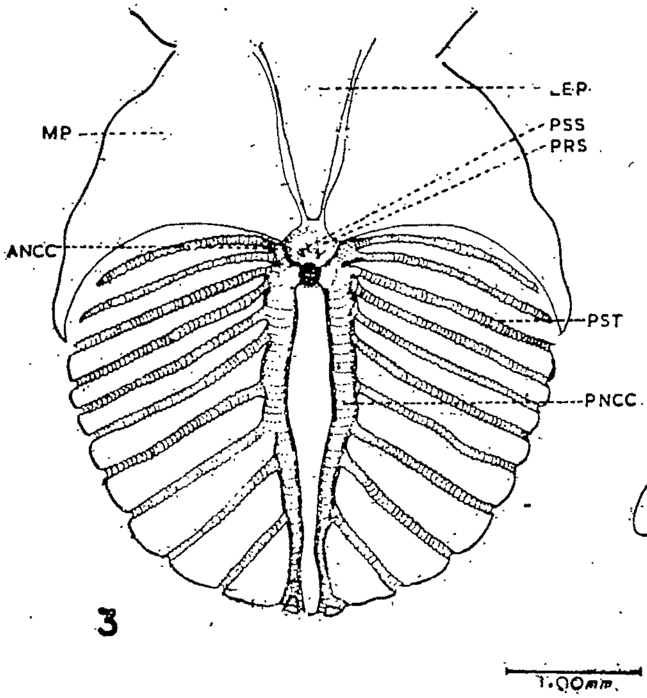
Fig. 1. Anterior view of the proboscis.

Fig. 2. Posterior view of the proboscis.

AB—Arched bar; BP—Basiproboscis; CLY—Clypeus; DP—Distiproboscis; ILM—Inter-labellar-membrane; LBS—Labellar sclerite; LEP—Labrum-epipharynx; LEPAP—Apodeme of the labrum-epipharynx; LPCLY—Lateral inflections of the clypeus; MP—Mediproboscis; MXP—Maxillary palp; PCLM—Periclypeal membrane; PRS—Prestomum; SB—Sensory bristles; TH—Theca.



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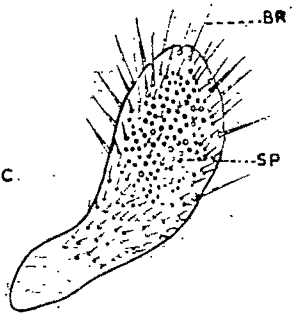

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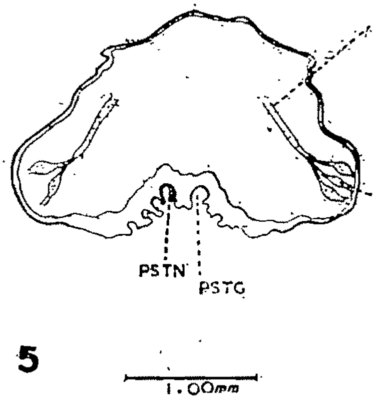

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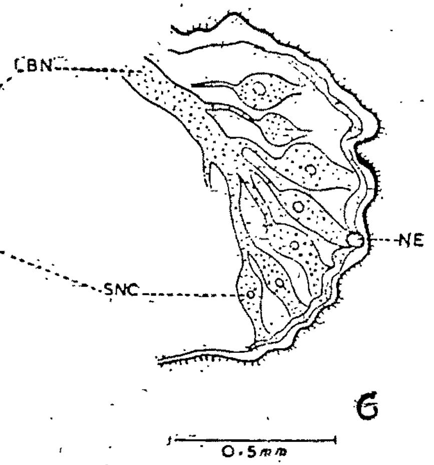

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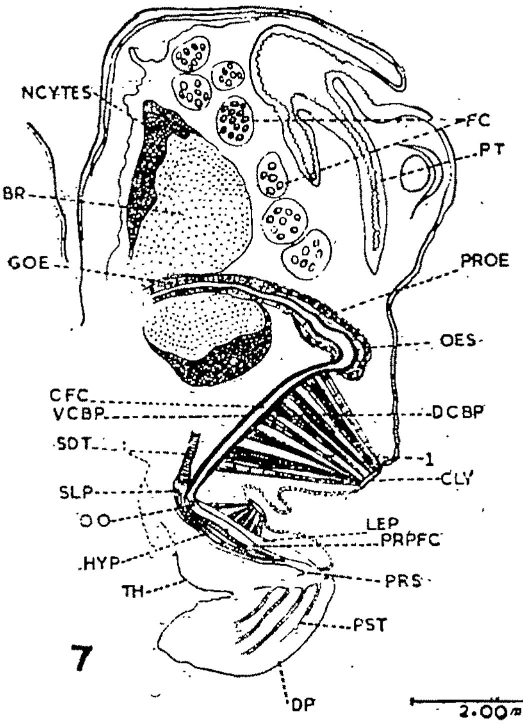
Fig. 3. Front view of the labella showing the arrangements of the pseudotrachea.
Fig. 4. Maxillary palp.
Fig. 5. Section of the labella showing pseudoctinidia.
Fig. 6. T. S. of the labella through the nerve endings.

ANCC—Anterior collecting channel; BR—Bristle; LBN—Labellar nerve; LEP—Labrum epipharynx; MP—Mediproboscis; NE—Nerve ending; PNCC—Posterior collecting channel; PRS—Prestomum; PSS—Prestomal spines; PST—Pseudotrachea; PSTG—Psuedotracheal groove; PSTN—Pseudoctinidia; SNC—Sensory cell; SP—Sensory pore.



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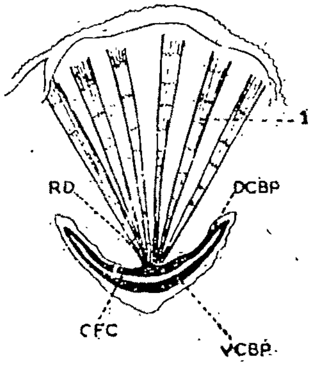

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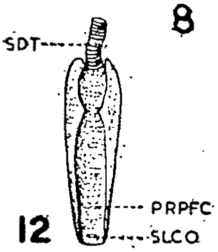

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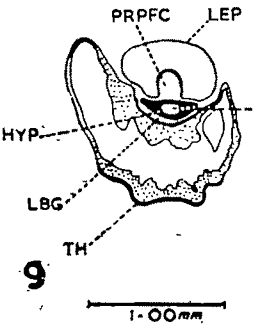

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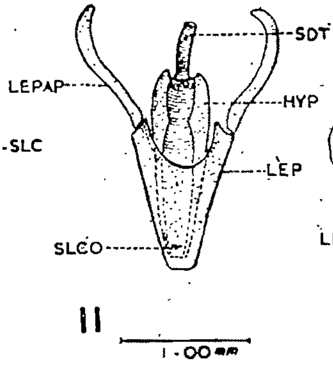

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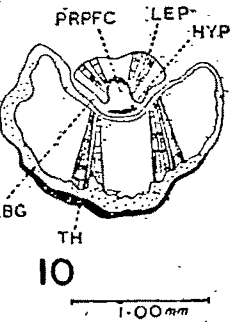

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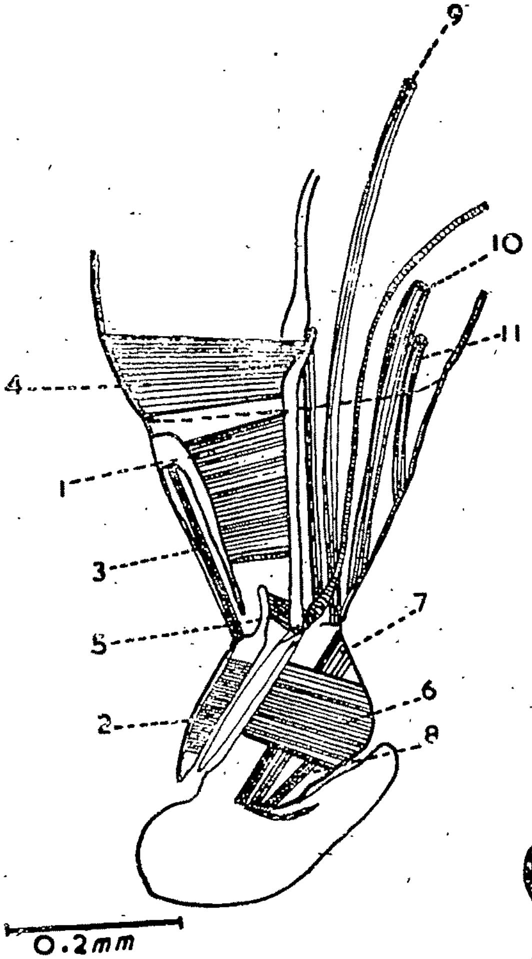
Fig. 7. Sagittal section of the head passing through the cibarium.
Fig. 8. T.S. through the cibarium.
Fig. 9. T.S. of the mediproboscis (proximal region).
Fig. 10. T.S. of the mediproboscis (distal region).
Fig. 11. Labrum-epipharynx and hypopharynx.
Fig. 12. Hypopharynx (anterior view).

BR—Brain; CFC—Cibarial food canal; CLY—Clypeus; DCBP—Dorsal (anterior) cibarial plate; DP—Distiproboscis; FC—Fat cells; GOE—Ganglionic oesophagus; HYP—Hypopharynx; LBG—Labial gutter; LEP Labrum-epipharynx; LEPAP—Apodeme of the labrum-epipharynx; NCYTES—Neurocytes; OES—Oesophagus; OO—Oral opening; PROE—Pre-ganglionic oesophagus; PRPFC—Pre-pharyngeal food canal; PRS—Prestomum; PST—Pseudotrachea; PT—Ptilinum; RD—Ridge; SDT—Salivary duct; SLC—Salivary canal; SLCO—Opening of the salivary canal; SLP—Salivary pump; TH—Theca; VCBP—Ventral (posterior) cibarial plate.



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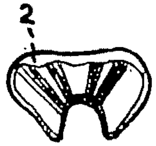

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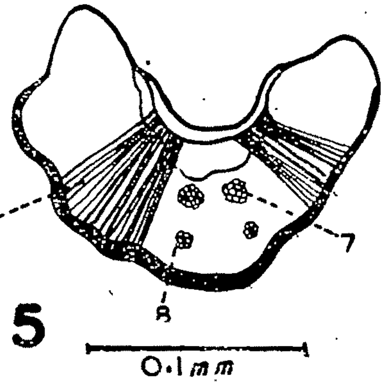

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Fig. 13. Lateral view of the head open to show the musculature.

Fig. 14. T.S. of the labrum-epipharynx.

Fig. 15. T.S. of the theca.

1—Pharyngeal dilators; 2—Dilators of the labrum-epipharynx; 3—Flexor of the labrum-epipharynx; 4—Retractor of the fulcrum; 5—Extensor of the haustellum; 6—Dilator of the labial gutter; 7—Extensor of the labella; 8—Retractor of the labella; 9—Retractor of the basiproboscis; 10—First accessory retractor of the basiproboscis; 11. Second accessory retractor of the basiproboscis.

STUDIES IN MALE STERILE BARLEY. I. FLORAL MORPHOLOGY, POLLINATION AND SEED-SET

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First report of male sterility in barley was made by Suneson (1940) and was explained due to a single pair of recessive genes. He has further demonstrated that this mutant can be used in the production of hybrid seeds (Suneson, 1962a). During the course of present study, male sterile plants have been discovered in a number of selections and a variety of barley. Studies on these male sterile barleys need immediate attention, so that the possibility of producing hybrid seeds in this crop is properly assessed under Indian conditions. The present paper, therefore, deals with the floral morphology, pollination and seed-set in these male sterile barleys.

MATERIAL AND METHODS

The material used in the present study consisted of a sample of composite-bulk seeds obtained from Dr. C. A. Suneson in 1961 and some Indian varieties of barley. First sowing of these was done in the season of 1961-62 at B. R. College Experimental Station, Bichpuri, Agra (India); and has been repeated up-to-date. Selections from which have so far resulted in the isolation of ten male sterile lines. Nine of these are from composite source while one is from an Indian variety N.P. 17. These isolates have been named as Male Sterile Bichpuri 1......10.*

Observations with regard to pollen and ovule fertility, nature and size of anthers at various stages of development and the seed set under natural and artificial conditions have been recorded for these male sterile plants. The extent of cross pollination in different male sterile lines was determined by the seed set under selfing, natural pollination and hand pollination of emasculated and unemasculated spikelets. To determine the significance of difference between different sets of observations "t" test was applied.

OBSERVATIONS AND RESULTS

The ten male sterile isolates on the basis of (i) number of fertile spikelets per node, (ii) presence of hoods or the awns and (iii) closed and open nature of the spikelets; can be classified into 5 types under two main groups as follows:—

(A) With open spikelets:

Type No. 1. Six-rowed hooded type (Ms. $B._1$ and $Ms.B._2$). Fig. 1.

Type No. 2. Two-rowed hooded type ($Ms.B._3$). Fig. 2.

Type No. 3. Six-rowed awned type ($Ms.B._4$ and $Ms.B._5$). Fig. 3.

Type No. 4. Two-rowed awned type. ($Ms.B._6$). Fig. 4.

(b) With closed spikelets :

Type No. 5. Six-rowed awned type ($Ms.B._7 \ldots {}_{10}$).

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* Abbreviated as Ms.B. 1.........10.

The open nature of spikelets in first four male sterile types is evident shortly after their emergence. This gives a characteristic broader appearance to the spikes than those of the male fertile plants (Figs. 1-4). On this basis the male sterile plants can be easily differentiated, with the exception of the type 3 (Fig. 3). In this case the male fertitle plants also have open spikelets just like the sterile ones (Figs. 3, 12). A closer view of an open spikelet reveals the presence of a space between lemma and palea (Figs. 5-8, 12), a feature which has been also observed by Suneson (1940) in the male sterile plants of barley under Californian conditions. Suneson (1962b) has also described a similar situation in Pugsley's sterile wheat, and considers it as a character which helps in increasing the chances of cross pollination.

The fifth type (Fig. 9) includes all those isolates where there is no space between lemma and palea, on account of which the spikelets remain closed. The male sterile isolate from N.P.$_{17}$ (Ms.B.$_{10}$) also belongs to this type. The fertile counter parts of the types 1, 2, 4 and 5 too possess closed type of spikelets (Figs. 1, 2, 3, 10, 11, 13, 14).

In male sterile plants of the Ms. B.$_{2}$ and Ms.B.$_{4}$, veins on the glumes are found to be green at the blooming stage while their fertile counterparts have a pinkish colouration. This serves as a marker for rouguing out the male fertile plants from the lines.

A comparative study of the size of anthers, from the male fertile and male sterile types at various stages of development has revealed that the length upto uninucleate pollen grain stage is almost same in types 1, 2 and 5 and slightly more in fertile counterparts of types 3 and 4. The breadth in all sterile types is smaller than their fertile counterparts. After this stage breadth in all sterile types and length in the sterile types 1, 3 and 4 shows very little increase. But the length in male sterile types 2 and 5 goes on increasing, which in type 2 even exceeds that of its fertile counterpart. Final measurements of mature anthers show that the length in all sterile types remains smaller than the corresponding fertile lines with the exception of type 2 (Fig. 15).

Pollen viability tests with acetocarmine have shown that pollen grains from sterile plants in general are empty, devoid of cytoplasm or nucleus and with shrivelled walls. They are mostly found to remain clumped together in the groups of varying numbers (Figs. 16-19). But those of the type 1 are found to be mostly free (Fig. 20). The pollen grains from the plants of the type 2 (Fig. 19) are smaller in size than rest of the types. The pollen grains from fertile plants on the contrary are turgid, full of cytoplasm and are released at trinucleate stage (Fig. 21).

Ovaries of the male sterile plants are found to be quite healthy (Figs.22-27) and on hand pollination 80-95 per cent seed-set has been obtained. No appreciable difference in the size or any other feature is obvious between the ovaries of any two counterparts. However, different types show some variation in shape and size, which is quite characteristic in type 2. The ovaries of this type are broader than in other lines (Fig. 27-b). This line has shown characteristic differences in respect of the size of anthers and pollen grains also.

Male sterile plants which are characterised by open spikelets exhibit a fairly good amount of cross pollination. The extent of successful pollination under selfing-, hand-and open-pollinated conditions during the season of 1964-65 are summarized in table 1.

TABLE 1

Amount of seed set in five male sterile types under various treatments[1]

Abb. N. C. Number of succesfully crossed spikes, P. S. Percentage seed set

Treatments	Selfing		HAND POLLINATION				OPEN POLLINATION					
			Hand pollinated		Emasculated and Hand pollinated		Open pollinated		Anthers removed and open pollinated		Palea and lemma cut and open pollinated	
Type Number	N.C.	P.S.	N.C.	P.S.	N.C.	P.S.	N C.	P.S.	N.C	P.S.	N.C.	P.S.
1.	1	0·5	5	95·50	5	94·00	5	69·00	5	70·60	5	74·90**
2.	0	0·0	5	92·00	5	91·90	5	59·40	5	59·30	5	63·00**
3.	0	0·0	5	85·00	5	80·52	5	41·00	5	42·40	5	50·00*
4.	0	0·0	5	80·00	5	83·00	5	40·00	5	40·80	5	46·40
5.	0	0·0	5	84·00	5	81·00	2	3·00	5	1·60	5	12·26*

[1] In each Treatment 5 spikes were pollinated. * Significant at ·05 level of probability. ** Significant at ·1 level of probability.

It is evident from table 1 that the male sterile plants do not produce seeds on selfing with the exception of one case of type 1, wherein the formation of 0·5 per cent seeds may be due to the contamination by foreign pollen. The table also reveals that maximum cross pollination has occurred in the hooded types. This agrees with the previous report of Suneson (1962a) with a natural cross pollination upto 70 per cent. The extent of cross pollination could be significantly increased in types 1, 2, 3 and 5 when upper part of their spikelets was cut to expose the stigma fully.

CONCLUSION

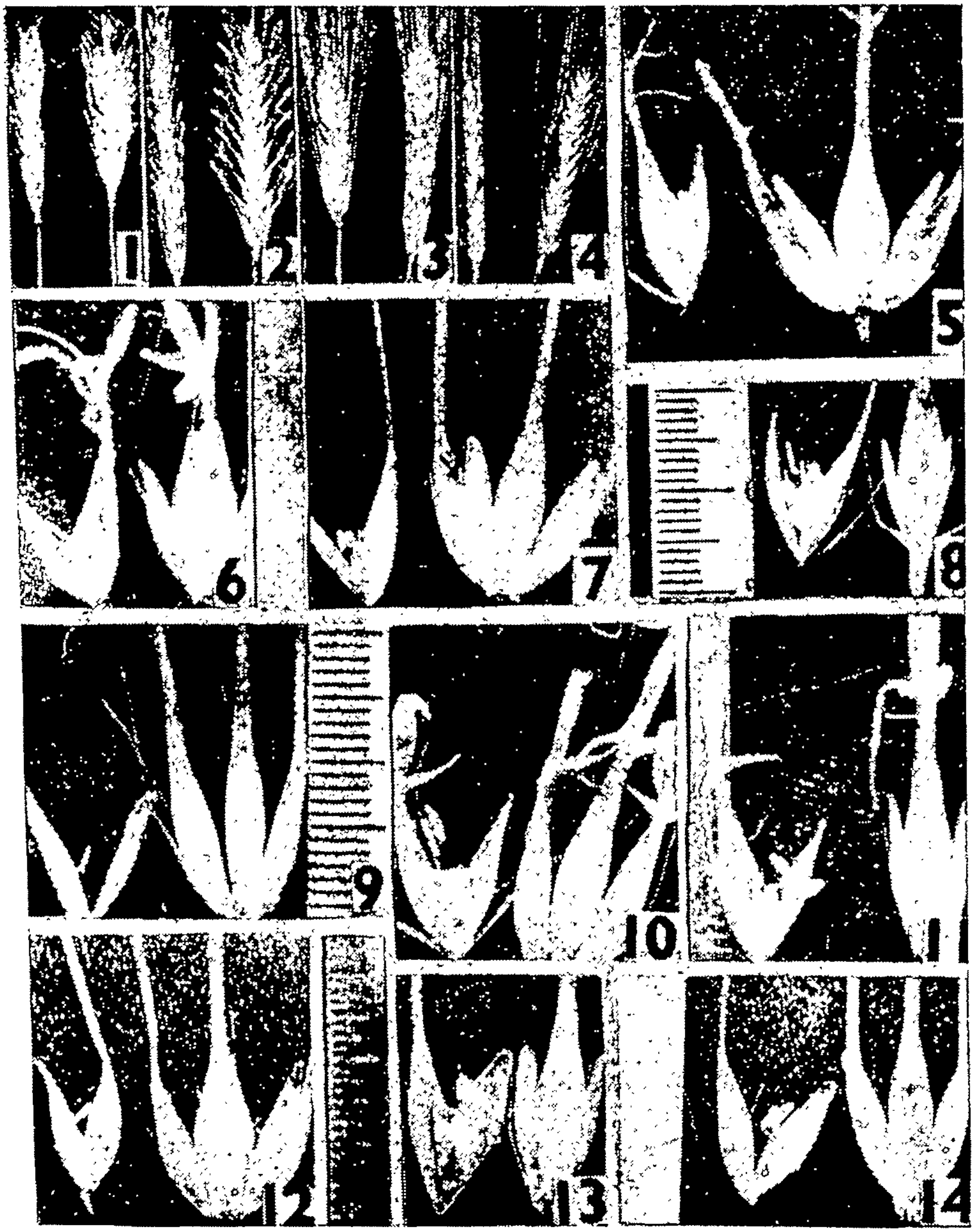
Exploitation of hybrid vigour for increasing the yield and quality of crop plants has assumed great importance during recent years. In case of barley, despite the fact that hybrid vigour has already been demonstrated (Suneson and Riddle, 1944; Grafius, 1959), its exploitation for economic use could not be made because of its strictly self pollinating character, which makes the production of hybrid seeds difficult and uneconomic. In the course of present study, some male sterile types have been discovered, which exhibit cross pollination to the extent of 70 per cent and can be even increased further to 75 per cent by clipping off the upper part of the spikelets. This is possible because of their open nature of the spikelets, making them suitable for large scale hybridization and an effective use in hybrid seed-production.

SUMMARY

Observations on a sample of composite-bulk of barley obtained from Dr. C. A. Suneson and some Indian varieties have been carried out. Ten male sterile lines have been isolated from composite bulk and N.P. 17, in two of which the colouration of veins on the glume in male fertile plants serves as a marker for rouguing out these plants from the line. Male sterile plants are perfectly female fertile and have produced as high as 95 per cent seed-set by hand pollination. Some of the male sterile types possess open nature of their spikelets, which has proved to be a very important manifestation for increasing the extent of cross pollination. Cross pollination to the extent of 70 per cent has been recorded in male sterile type 1, which could be further increased to nearly 75 per cent by clipping off the upper portion of their spikelets.

REFERENCES

1. Grafius, J.E. 1959. Heterosis in barley. *Agron.J.*, **51** : 551-554.
2. Suneson, C. A. 1940. A male-sterile character in barley. *J. Heredity*, **31**: 213-214.
3. Suneson, C. A. 1962a. Hybrid barley promises high yield. *Crop Sci.*, **2** : 410-411.
4. Suneson, C. A. 1962b. Use of Pugsley's sterile wheat in cross breeding. *Crop Sci.*, **2** : 534-535.
5. Suneson, C. A. & Riddle, O.C. 1944. Hybrid vigour in barley. *J. Am. Soc. Agron.*, **36**: 57-61.



Explanation of Plate I—See page......

Plate I Figs. 1-14 : Photographs of the spikes and spikelets of male fertile and male sterile types of barley. Figs. 1, 5 - male sterile type 1; Figs. 2, 6 - male sterile type 2; Figs. 3, 7—male sterile type 3; Figs. 4, 8—male sterile type 4; Fig. 9—male sterile type 5; Figs. 10, 11, 12, 13 and 14—male fertile types 1, 2, 3, 4 and 5 respectively.

Figs. 1-4 : In each figure the spike on the left is of fertile plant, while on the right from the sterile one. Note the broader nature of the male sterile spikes.

Figs. 5-9 : Spikelets from the five male sterile types to show their anthers and their natural degree of opening. On the left in each type is a photograph of a slightly opened spikelet to expose their anthers to view. On the right are the three spikelets of a node showing the degree of their natural opening. Note that types 1, 2, 3 and 4 (Figs. 5-8) have open nature of their spikelets while type 5 (Fig. 9) has the closed nature.

Figs. 10-14 : Spikelets from the five male fertile types to show their anthers and the normal closed nature. On the left in each type is a photograph of a slightly opened spikelet to expose the anthers to view. On the right are the three spikelets of a node showing the normal closed nature. Note that the type 3 (Fig. 12) possesses the open nature.

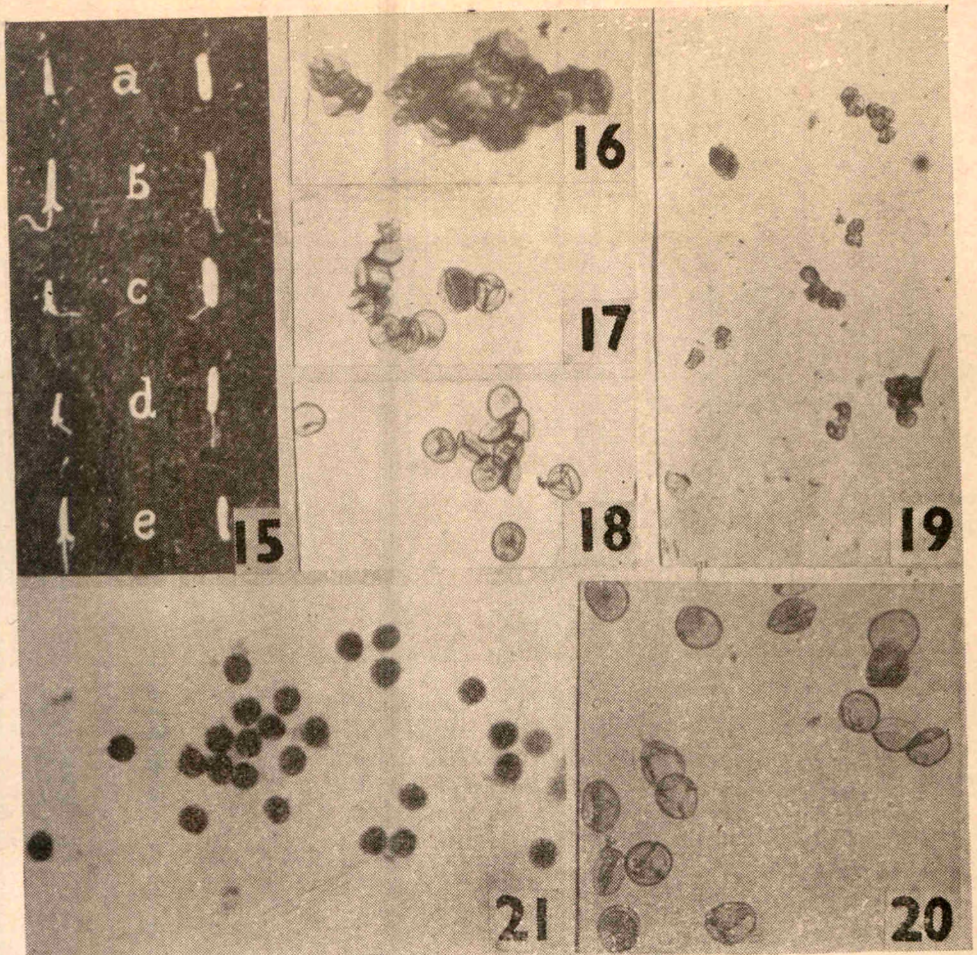


Plate II Figs. 15-21 : Anthers and pollen grains from male sterile and male fertile plants.

Fig. 15 : Showing anthers from the male sterile (left) and male fertile (right) plants. %2

Figs. 16-19 : Pollen grains from male sterile types 3, 4, 5 and 2 respectively, clumped in the groups of varying numbers. Note the smaller size of pollen grains in type 2. %250

Fig. 20 : Showing isolated, lightly stained, sterile pollen grains from male sterile type 1. %250

Fig. 21 : Showing pollen grains from a male fertile plant. %200

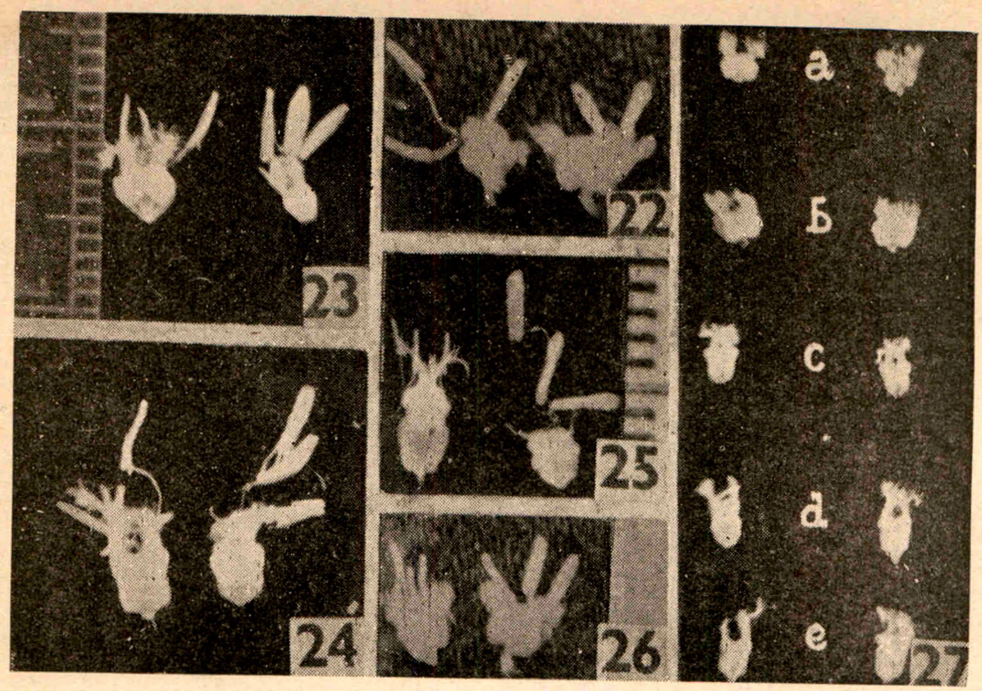


Plate III Figs. 22-27: Photographs of the ovaries and anthers from the five male sterile and male fertile types of barley.

Figs. 22-26 : Showing the ovaries and anthers from the five male sterile (left) and male fertile (right) lines of the types 1-5.

Fig. 27 : Comparing the size of ovaries from male sterile (left) and male fertile (right) plants of types 1-5 (a-e).

SOME THEOREMS ON SELF-RECIPROCAL FUNCTIONS IN GENERALIZED HANKEL TRANSFORM $\chi_{\nu, k, m}$

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1. A function is said to be self-reciprocal function of order ν, where R*e* $\nu > -1$, in the Hankel transform, if it satisfies the integral equation

$$f(x)=\int_0^{\infty} (xy)^{\frac{1}{2}} J_{\nu} (xy)\, f(y)\, dy \qquad ..(1{\cdot}1)$$

and is denoted by R_{ν}.

Roop Narain[5] has developed the theory of functions which are self-reciprocal in the generalized Hankel transform, viz.,

$$f(t)=\frac{1}{2^{\nu}}\int_0^{\infty} (ty)^{\nu+\frac{1}{2}}\, \chi_{\nu,k,m}(\tfrac{1}{4}x^2 y^2)\, f(y)\, dy, \qquad ..(1{\cdot}2)$$

where

$$\chi_{\nu,k,m}(x)=\frac{\Gamma(2m)\Gamma\left(\frac{3}{2}+\nu+m-k\right)}{\Gamma(\frac{1}{2}-k+m)\,\Gamma_*^{(1)}(1+\nu+m\pm m)}\; {}_2F_3\left[\begin{matrix}\frac{1}{2}+k-m,\ \frac{3}{2}+\nu+m-k; \\ 1-2m,\ 1+\nu+m\pm m;\end{matrix}\ -x\right]$$
$$+\frac{\Gamma(-2m)\,\Gamma\left(\frac{3}{2}+\nu+3m-k\right)}{\Gamma(\frac{1}{2}-k-m)\Gamma_*(1+\nu+3m\pm m)}\; {}_2F_3\left[\begin{matrix}\frac{1}{2}+k-m,\ \frac{3}{2}+\nu+3m-k; \\ 1+2m,\ 1+\nu+3m\pm m;\end{matrix}\ -x\right]$$
$$=x^{-\nu}\, G^{2,\,1}_{2,\,4}\left(x\,\middle|\,\begin{matrix}k-m-\frac{1}{2},\ \frac{1}{2}+\nu-k+m \\ \nu,\ \nu+2m,\ -2m,\ 0\end{matrix}\right)$$

and he has denoted such function by R_{ν} (K, *m*).

He[6] also proved that a necessary and sufficient condition that a function $f(x)$ of A (α, a) be R_{ν} (k, m) is that it should be of the form

$$f(x)=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} 2^{\frac{1}{2}s}\, \frac{\Gamma_*(\frac{1}{2}\nu+\frac{1}{2}s+\frac{1}{4}+m\pm m)}{\Gamma(\frac{1}{2}\nu+\frac{1}{2}s+\frac{3}{4}+m-k)}\, \psi(s)x^{-s}\, ds \qquad ..(1{\cdot}3)$$

---

(1) $\Gamma_*(a\pm b)$ denotes $\Gamma(a+b).\ \Gamma(a-b)$

where $\psi(s)$ is regular, satisfies the equation

$$\psi(s)=\psi(1-s)$$

in the strip

$$a<\sigma<1-a;\ s=\sigma+it \qquad ..(1{\cdot}4)$$

According to Titchmarsh $f(x)$ belongs to $A(\alpha, a)$, where $0<\alpha\leqslant\frac{\pi}{2}$, $a<\frac{1}{2}$, if (i) it is an analytic function of $x=re^{i\theta}$ regular in the angle defined by $r>0$, $|\theta|<\alpha$, and (ii) it is $0(|x|^{-a-\varepsilon})$ for small x, and $0(|x|^{a-1+\varepsilon})$ for large x, for every positive ε and uniformly in any angle $|\theta|\leqslant\alpha-\eta<\alpha$.

Also, $\psi(s)=0\left\{e^{\left(\frac{\pi}{4}-\alpha+\eta\right)|t|}\right\}$ for every positive η and uniformly in any strip interior to (1·4); and c is any value of σ in (1·4). In particular, when $k+m=\frac{1}{2}$; (1·2) yields the well known Hankel transform (1·1).

The object of this paper is to investigate certain theorems concerning functions which are self-reciprocal in the generalized Hankel transform $\chi_{\nu,k,m}$. Few self-reciprocal functions have also been determined.

2. Theorem 1(a). If

$$P(x)=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty}2^{(b+\frac{1}{2})s}\frac{\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)}\times$$

$$\times\frac{\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)\Gamma_*\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{1}{4}+p\pm p\right)}{\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)\Gamma\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{3}{4}+p-q\right)}w(s)x^{-s}ds \qquad ..(1)$$

where

$$w(s)=w(1-s) \qquad ..(2)$$

in the strip

$$a<\sigma<1-a \qquad ..(3)$$

$$w(s)=0\left\{e^{\left(\frac{3\pi}{4}-3\alpha+3\eta\right)|t|}\right\}$$

for every positive η and uniformly in any strip interior to (3); and c is any value of σ in (3);

and

$$f(x)=\frac{1}{2\pi i}\int_{c'-i\infty}^{c'+i\infty}2^{bs}\frac{\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)}$$

$$\times\chi(s)x^{-s}\,ds \qquad ..(4)$$

where $\chi(s)$ satisfies (2) in the strip (3), and

$$\chi(s)=0\left\{ e^{\left(\frac{\pi}{2}-2a+2\eta\right)|t|} \right\} \qquad ..(5)$$

then the function

$$g(x)=\int_0^\infty \mathrm{P}(xy)\, f(y)\, dy \qquad ..(6)$$

is $\mathrm{R}_\varepsilon\ (q, p)$ and belongs to $\mathrm{A}(5a, a)$.

Proof—By (1) we have

$$g(x)=\frac{1}{2\pi i}\int_0^\infty f(y)dy\int_{c-i\infty}^{c+i\infty} 2^{(b+\frac12)s}\,\frac{\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)}\times$$

$$\times\frac{\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)\Gamma_*\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{1}{4}+p\pm p\right)}{\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)\Gamma\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{3}{4}+p-q\right)}\times w(s)(xy)^{-s}\, ds \qquad ..(7)$$

$$=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} 2^{(b+\frac12)s}\times$$

$$\frac{\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)\Gamma_*\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{1}{4}+p\pm p\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)\Gamma\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{3}{4}+p-q\right)}$$

$$\times\ w(s)\, x^{-s}\, ds\int_0^\infty y^{-s}\, f(y)dy \qquad ..(8)$$

To justify the inversion in the order of integration, we observe that the modulus of the repeated integral is not greater than a constant multiple of

$$x^{-c}\int_{-\infty}^{\infty} 2^{(b+\frac12)s}\left|\frac{\Gamma_*\left(\frac{\nu}{2}+\frac14+m\pm m+\frac12 c+\frac12 ct\right)\Gamma_*\left(\frac{\lambda}{2}+\frac14+n\pm n+\frac12 c+\frac12 it\right)}{\Gamma\left(\frac{\nu}{2}+\frac34+m-k+\frac12 c+\frac12 it\right)\Gamma\left(\frac{\lambda}{2}+\frac34+n-l+\frac12 c+\frac12 it\right)}\times\right.$$

$$\left.\times\frac{\Gamma_*\left(\frac{\varepsilon}{2}+\frac14+p\pm p+\frac12 c+\frac12 it\right)}{\Gamma\left(\frac{\varepsilon}{2}+\frac34+p-q+\frac12 c+\frac12 it\right)}\right|\ |w(s)|\, dt\times\int_0^\infty y^{-c}\ |f(y)\, dy| \qquad ..(9)$$

The inversion in the order of integration will be justified if the two integrals separately exist.

Now by virtue of (2) and

$$\left|\Gamma(B+it)\right| \backsim C e^{-\frac{\pi}{2}|t|} \, |t|^{B-\frac{1}{2}} \qquad \ldots(10)$$

the integrand in the t-integral is substantially the same as

$$e^{-3(a-\eta)|t|} \, |t|^{-\frac{9}{4}+\frac{1}{2}\nu+\frac{1}{2}\lambda+\frac{1}{2}\varepsilon+m+n+q+k+p+1+\frac{3}{2}c}$$

Hence the t-integral exists for $(a-\eta)>0$.

Also by virtue of (5) and (10), the modulus of the integrand in (5) is not greater than a constant multiple of

$$e^{-2(a-\eta)|t|} \, |t|^{-\frac{8}{3}+\frac{1}{2}\nu+\frac{1}{2}\lambda+m+n+k+l+c'} x^{-c'}$$

Therefore the integral (4) is uniformly convergent for $a>\eta$.

Also, $f x) \backsim |x|^{-c'}$, and since c' may be taken as near c or 1-c as we please, it follows that y-integral in (9) also converges. Hence the inversion of the order of integration in (7) is justifiable.

Now by applying Mellin's inversion formula to (4), we have

$$\int_0^\infty x^{s-1} f(x)dx = 2^{bs} \frac{\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)} \chi(s)$$

Thus

$$\int_0^\infty x^{-s} f(x)dx = 2^{b(1-s)} \frac{\Gamma_*\left(\frac{\nu}{2}-\frac{s}{2}+\frac{3}{4}+m\pm m\right)\Gamma_*\left(\frac{\lambda}{2}+\frac{3}{4}+\frac{s}{2}+n\pm n\right)}{\Gamma\left(\frac{\nu}{2}+\frac{5}{4}-\frac{s}{2}+m-k\right)\Gamma\left(\frac{\lambda}{2}-\frac{s}{2}+\frac{5}{4}+n-l\right)} \chi(s),$$

since $\chi(s)=\chi(1-s)$

Hence, from (8), we have

$$g(x) = \frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} 2^{(b+\frac{1}{2})s} \frac{\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)} \times$$

$$\times \frac{\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)\Gamma_*\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{1}{4}+p\pm p\right)}{\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)\Gamma\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{3}{4}+p-q\right)} x^{-s} \chi(s) \, w(s) \, 2^{b(1-s)} \times$$

$$\times \frac{\Gamma_*\left(\frac{\nu}{2}+\frac{3}{4}-\frac{s}{2}+m\pm m\right)\Gamma_*\left(\frac{\lambda}{2}+\frac{3}{4}-\frac{s}{2}+n\pm n\right)}{\Gamma\left(\frac{\nu}{2}-\frac{s}{2}+\frac{5}{4}+m-k\right)\Gamma\left(\frac{\lambda}{2}-\frac{s}{2}+\frac{5}{4}+n-l\right)},$$

$$=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} 2^{\frac{1}{2}s}\,\frac{\Gamma_*\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{1}{4}+p\pm p\right)}{\Gamma\left(\frac{\varepsilon}{2}+\frac{s}{2}+\frac{3}{4}+p-q\right)}\,x^{-s}\,\psi_1(s)\,ds,$$

where

$$\psi_1(s)=\frac{2^b\,\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)\Gamma_*\left(\frac{\nu}{2}-\frac{s}{2}+\frac{3}{4}+m\pm m\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)\Gamma\left(\frac{\nu}{2}+\frac{5}{4}-\frac{s}{2}+m-k\right)}\times$$

$$\times\frac{\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)\Gamma_*\left(\frac{\lambda}{2}-\frac{s}{2}+\frac{3}{4}+n\pm n\right)}{\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)\Gamma\left(\frac{\lambda}{2}+\frac{5}{4}-\frac{s}{2}+n-l\right)}\times\lambda(s)\,w(s)$$

$$=\psi_1(1-s)$$

It follows that $g(x)$ belongs to $A(5a, a)$ and is $R_{\varepsilon}\;(q, p)$.

For $b=1$, $k+m=\frac{1}{2}$, $n+l=\frac{1}{2}$ and $p+q=\frac{1}{2}$, this theorem reduces to the corresponding theorem in Hankel transform of one variable due to Brij Mohan [3].

Theorem 1(a) can be generalized as follows:—

Theorem 1(b). If

$$P(x)=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} 2^{(b+\frac{1}{2})s}\,\frac{\Gamma_*\left(\frac{\nu_1}{2}+\frac{s}{2}+\frac{1}{4}+m_1\pm m_1\right)\cdots\cdots}{\Gamma\left(\frac{\nu_1}{2}+\frac{s}{2}+\frac{3}{4}+m_1-k_1\right)\cdots\cdots}\,\frac{\Gamma_*\left(\frac{\nu_n}{2}+\frac{s}{2}+\frac{1}{4}+m_n\pm m_n\right)}{\Gamma\left(\frac{\nu_n}{2}+\frac{s}{2}+\frac{3}{4}+m_n-k_n\right)}\,x^{-s}\,w(s)\,ds \quad ..(11)$$

where $w(s)$ satisfies (2) in the strip (3), and

$$w(s)=0\left\{e^{\left(\frac{n\lambda}{4}-na+n\eta\right)|t|}\right\};$$

and

$$f(x)=\frac{1}{2\pi i}\int_{c'-i\infty}^{c'+i\infty} 2^{bs}\,\frac{\Gamma_*\left(\frac{\nu_1}{2}+\frac{s}{2}+\frac{1}{4}+m_1\pm m_1\right)\cdots\cdots}{\Gamma\left(\frac{\nu_1}{2}+\frac{s}{2}+\frac{3}{4}+m_1-m_1\right)\cdots\cdots}\,\frac{\Gamma_*\left(\frac{\nu_{n-1}}{2}+\frac{s}{2}+\frac{1}{4}+m_1\pm m_1\right)}{\Gamma\left(\frac{\nu_{n-1}}{2}+\frac{s}{2}+\frac{3}{4}+m_{n-1}-k_{n-1}\right)}\,x^{-s}\,\chi(s)\,ds \quad ..(12)$$

where $\chi(s)$ satisfies (2) in the strip (3) and

$$\chi(s)=0\left\{ e^{\left[\frac{n-1}{4}\pi-(n-1)a+(n-1)\eta\right]|t|} \right\}$$

then the function

$$g(x)=\int_0^\infty P(xy)\, f(y)\, dy \qquad ..(13)$$

is $R_{\nu_n}(k_n, m_n)$ and belongs to $A\{(2n-1)a, a\}$

For $k_1+m_1=k_2+m_2 \ldots\ldots k_n+m_n=\frac{1}{2}$, this theorem reduces to the corresponding theorem in the Hankel transform of one variable due to B. D. Agarwal[1].

Theorem 2(a). If

$$P(x)=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} 2^{bs}\frac{\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)} \frac{\Gamma_*\left(\frac{\varepsilon}{2}-\frac{s}{2}+\frac{3}{4}+p\pm p\right)}{\Gamma\left(\frac{\varepsilon}{2}-\frac{s}{2}+\frac{5}{4}+p+q\right)} w(s)x^{-s}\, ds \qquad ..(14)$$

where $w(s)$ satisfies (2) in the strip (3) and

$$w(s)=\left[e^{\left(\frac{3}{4}\pi-a+\eta\right)|t|}\right]$$

and

$$f(x)=\frac{1}{2\pi i}\int_{c'-i\infty}^{c'+i\infty} 2^{(b+\frac{1}{2})s}\frac{\Gamma_*\left(\frac{\nu}{2}+\frac{s}{2}+\frac{1}{4}+m\pm m\right)\Gamma_*\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{1}{4}+n\pm n\right)}{\Gamma\left(\frac{\nu}{2}+\frac{s}{2}+\frac{3}{4}+m-k\right)\Gamma\left(\frac{\lambda}{2}+\frac{s}{2}+\frac{3}{4}+n-l\right)}\times \chi(s)x^{-s}\, ds, \qquad ..(15)$$

where $\chi(s)$ satisfies (2) in the strip (3) and

$$\chi(s)=0\left\{ e^{\left(\frac{1}{2}\pi+2\eta-2a\right)|t|} \right\},$$

then the function

$$g(x)=\int_0^\infty P(x) f(xy)\, dy \qquad ..(16)$$

is $R_\varepsilon(q, p)$ and belongs to $A(3a, a)$.

For $b=\frac{1}{2}$, $k+m=n+1=p+q=\frac{1}{2}$, this theorem reduces to the corresponding theorem in Hankel transform of one variable due to Brij Mohan[2]. This theorem can be generalized as follows:—

Theorem 2(b). If

$$P(x)=\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty}2^{bs}\frac{\Gamma_*\left(\frac{\nu_1}{2}+\frac{s}{2}+\frac{1}{4}+m_1\pm m_1\right)\cdots\cdot}{\Gamma\left(\frac{\nu_1}{2}+\frac{s}{2}+\frac{3}{4}+m_1-k_1\right)\cdots\cdot}$$

$$\frac{\Gamma_*\left(\frac{\nu_{n-1}}{2}+\frac{s}{2}+\frac{1}{4}+m_{n-1}\pm m_{n-1}\right)\Gamma_*\left(\frac{\nu_n}{2}-\frac{s}{2}+\frac{3}{4}+m_n\pm m_n\right)}{\Gamma\left(\frac{\nu_{n-1}}{2}+\frac{s}{2}+\frac{3}{4}+m_{n-1}-k_{n-1}\left(\ \Gamma\left(\frac{\nu_n}{2}-\frac{s}{2}+\frac{5}{4}+m_n-k_n\right)\right.\right.}w(s)x^{-s}\,ds \qquad ..(17)$$

where $w(s)$ satisfies (2) in the strip (3) and

$$w(s)=0\left[e^{\{\frac{1}{4}n\pi-(n-2)a+(n-2)\eta\}\,|\,t\,|}\right],$$

and

$$f(x)=\frac{1}{2\pi i}\int_{c'-i\infty}^{c'+i\infty}2^{(b+\frac{1}{2})s}\frac{\Gamma_*\left(\frac{\nu_1}{2}+\frac{s}{2}+\frac{1}{4}+m_1\pm m_1\right)\cdots\cdot}{\Gamma\left(\frac{\nu_1}{2}+\frac{s}{2}+\frac{3}{4}+m_1-k_1\right)\cdots\cdot}$$

$$\frac{\Gamma_*\left(\frac{\nu_{n-1}}{2}+\frac{s}{2}+\frac{1}{4}+m_{n+1}\pm m_{n-1}\right)}{\Gamma\left(\frac{\nu_{n-1}}{2}+\frac{s}{2}+\frac{3}{4}+m_{n-1}\pm m_{n-1}\right)}\chi(s)x^{-s}\,ds \qquad ..(18)$$

where $\chi(s)$ satisfies (2) in the strip (3) and

$$\chi(s)=0\left\{e^{[\frac{1}{4}(n-1)\pi-(n-1)a+(n-1)\eta]\,|\,t\,|}\right\},$$

then the function

$$g(x)=\int_0^\infty P(y)f(xy)\,dy \qquad ..(19)$$

is $R_{\nu_n}(k_n,\,m_n)$ and belongs to $A[(2n-3)a,\,a]$.

For $k_1+m_1=k_2+m_2=\ldots\ldots k_n+m_n=\frac{1}{2}$, the above theorem reduces to the corresponding theorem in the Hankel transform of one variable due to B. D. Agarwal[1].

Corollary 1. Theorems 1 and 2 are true even when $w(s)$ and $\chi(s)$ satisfy the relations

$$\left.\begin{aligned} w(s) &= w(1-s) \\ \chi(s) &= \chi(1-s) \end{aligned}\right\} \qquad \ldots (20)$$

Corollary 2. If one of the functions $w(s)$, $\chi(s)$ in the theorems 1 and 2 satisfy (2) and the other (20), the function $g(x)$ is $-\mathrm{R}_{\nu_n}(k_n, m_n)$.

Example. If $b=1$ and $w(s)=\chi(s)=\frac{1}{2}$ in the Theorem 1(a), then on using Mellin transform [4], p. 337, (14), we have

$$\mathrm{P}(x) = G^{6,\,0}_{3,\,6}\left(\frac{x^2}{4}\left|\begin{matrix} \frac{\nu}{2}+\frac{3}{4}+m-k,\ \frac{\lambda}{2}+\frac{3}{4}+n-l,\ \frac{\varepsilon}{2}+\frac{3}{4}+p-q \\ \frac{\nu}{2}+\frac{1}{4},\ \frac{\nu}{2}+\frac{1}{4}+2m,\ \frac{\lambda}{2}+\frac{1}{4},\ \frac{\lambda}{2}+\frac{1}{4}+2n,\ \frac{\varepsilon}{2}+\frac{1}{4},\ \frac{\varepsilon}{2}+\frac{1}{4}+2p \end{matrix}\right.\right)$$

$$f(x) = G^{4,\,0}_{2,\,4}\left(\frac{x^2}{4}\left|\begin{matrix} \frac{\nu}{2}+\frac{3}{4}+m-k,\ \frac{\lambda}{2}+\frac{3}{4}+n-l \\ \frac{\nu}{2}+\frac{1}{4},\ \frac{\nu}{2}+\frac{1}{4}+2m,\ \frac{\lambda}{2}+\frac{1}{4},\ \frac{\lambda}{2}+\frac{1}{4}+2n \end{matrix}\right.\right)$$

and hence

$$g(x) = \int_0^\infty G^{6,\,0}_{3,\,6}\left(\frac{x^2y^2}{4}\left|\begin{matrix} \frac{\nu}{2}+\frac{3}{4}+m-k,\ \frac{\lambda}{2}+\frac{3}{4}+n-l,\ \frac{\varepsilon}{2}+\frac{3}{4}+p-q \\ \frac{\nu}{2}+\frac{1}{4},\ \frac{\nu}{2}+\frac{1}{4}+2m,\ \frac{\lambda}{2}+\frac{1}{4},\ \frac{\lambda}{2}+\frac{1}{4}+2n,\ \frac{\varepsilon}{2}+\frac{1}{4},\ \frac{\varepsilon}{2}+\frac{1}{4}+2p \end{matrix}\right.\right) \times$$

$$\times G^{4,\,0}_{2,\,4}\left(\frac{y^2}{4}\left|\begin{matrix} \frac{\nu}{2}+\frac{3}{4}+m-k,\ \frac{\lambda}{2}+\frac{3}{4}+n-l \\ \frac{\nu}{2}+\frac{1}{4},\ \frac{\nu}{2}+\frac{1}{4}+2m,\ \frac{\lambda}{2}+\frac{1}{4},\ \frac{\lambda}{2}+\frac{1}{4}+2n \end{matrix}\right.\right) dy$$

$$= G^{6,\,4}_{7,\,8}\left(x^2\left|\begin{matrix} \frac{1}{4}-\frac{\nu}{2},\ \frac{1}{4}-\frac{\nu}{2}-2m,\ \frac{1}{4}-\frac{\lambda}{2},\ \frac{1}{4}-\frac{\lambda}{2}-2n,\ \frac{3}{4}+\frac{\nu}{2}+m-k,\ \frac{3}{4}+\frac{\lambda}{2}+n-l,\ \frac{3}{4}+\frac{\varepsilon}{2}+p-q \\ \frac{1}{4}+\frac{\nu}{2},\ \frac{1}{4}+\frac{\nu}{2}+2m,\ \frac{1}{4}+\frac{\lambda}{2},\ \frac{1}{4}+\frac{\lambda}{2}+2n,\ \frac{1}{4}+\frac{\varepsilon}{2},\ \frac{1}{4}+\frac{\varepsilon}{2}+2p,\ \frac{1}{4}-\frac{\nu}{2}-m+k,\ -\frac{1}{4}-\frac{\lambda}{2}-n+l \end{matrix}\right.\right)$$

which is $\mathrm{R}_{\varepsilon}(q, p)$.

For $k+m=n+l=p+q=\frac{1}{2}$, we get

$$G^{3,2}_{2,3}\left(x^2\,\middle|\,\begin{matrix}\frac{1}{4}-\frac{\nu}{2},\ \frac{1}{4}-\frac{\lambda}{2}\\ \frac{1}{4}+\frac{\nu}{2},\ \frac{1}{4}+\frac{\lambda}{2},\ \frac{1}{4}+\frac{\varepsilon}{2}\end{matrix}\right)$$

as R_{ε}.

Extending these results we get

$$g(x)=G^{2n,\,2n-2}_{3n-2,3n-1}\left(x^2\,\middle|\,\begin{matrix}\frac{1}{4}-\frac{\nu_1}{2},\ \frac{1}{4}-\frac{\nu_1}{2}-2m_1\ldots\frac{1}{4}-\frac{\nu_{n-1}}{2},\ \frac{1}{4}-\frac{\nu_{n-1}}{2}-2m_{n-1},\\ \frac{1}{4}+\frac{\nu_1}{2},\ \frac{1}{4}+\frac{\nu_1}{2}+2m_1,\ldots\frac{1}{4}+\frac{\nu_n}{2},\ \frac{1}{4}+\frac{\nu_n}{2}+2m_n,\end{matrix}\right.$$

$$\left.\begin{matrix}\frac{3}{4}+\frac{\nu_1}{2}+m_1-k_1,\ldots-\frac{3}{4}+\frac{\nu_n}{2}+m_n-k_n\\ -\frac{1}{4}-\frac{\nu_1}{2}-m_1+k_1,\ldots-\frac{1}{4}-\frac{\nu_{n-1}}{2}-m_{n-1}+k_{n-1}\end{matrix}\right)$$

as $R_{\nu_n}(k_n,\ m_n)$,

and

$$G^{n,\,n-1}_{n-1,\,n}\left(x^2\,\middle|\,\begin{matrix}\frac{1}{4}-\frac{\nu_1}{2},\ldots\ldots,\frac{1}{4}-\frac{\nu_{n-1}}{2}\\ \frac{1}{4}+\frac{\nu_1}{2},\ldots\ldots,\frac{1}{4}+\frac{\nu_n}{2}\end{matrix}\right)$$

as R_{ν_n}.

REFERENCES

1. Agarwal, B. D. 1958. *Bull. Cal. Math. Soc.*, Vol. 50, Supp.
2. Brij Mohan 1939. *Quart. Jour. of Math.* (Oxf. Series) Vol. 10.
3. Brij Mohan 1940. *Jour. Ind. Math. Soc.* New Series, 5.
4. Erdelyi, A. 1954. *Tables of Integral Transform* Vol. 2.
5. Roop Narain 1956. *Universita E Politecnico Di Torino* Vol. 15.
6. ,, 1957 *Ibid*, Vol. 16.

ON THE INTERFACIAL REGION NEAR THE ORIGIN OF A POLYTROPE

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In a complete polytrope, the origin and the rest of the parts of the configurations are governed by solutions of Lane-Emden equations of index, n for two different values of n. In the present paper, the radial distance, upto which solutions relevant at the origin, has been determined.

In the paper by Shambhunath[2], it has been shown that r and P are the most suitable variables for the study of the structure of a polytropic configuration. In a polytrope, the solution of

$$\frac{u}{v}\frac{dv}{du}=-\frac{(n+1)-v-(n+1)\,u}{3\,(n+1)-nv-(n+1)\,u} \qquad ..(1)$$

for $n=-1$, governs the origin and in the rest of the configuration equation (1) is relevant for any value of n. Since there is a continuity at the origin, there must exist an interfacial region, to which solutions both relevant at the origin and in the rest of the configuration are relevant simultaneously.

Lane-Emden equation in terms of ξ and P can be written as

$$\frac{1}{\xi^2}\frac{d}{d\xi}\left(\xi^2 P^{-\frac{n}{n+1}}\frac{dP}{d\xi}\right)=-P^{\frac{n}{n+1}} \qquad ..(2)$$

where dimensionless variable ξ is defined as

$$r=a\xi;\; a^2=\left[\frac{K^{\frac{2n}{n+1}}}{4\pi G}\right] \qquad ..(3)$$

The above equation (2) is not solvable for general values of n, we take the series solution of (2) near the origin.

Without the loss of generality, we can take the central pressure to be unity. Let us therefore assume the solution of (2) near the origin in the form of the series

$$P=1+c\xi^2+d\xi^4+\ldots\ldots\ldots \qquad ..(4)$$

at the origin $\xi=0$ gives $P=1$ and $\frac{dP}{d\xi}=0$. By substituting the foregoing series (4) in the equation (2) and by equating the coefficients of like powers, we determine c and d. Thus the series including the first three terms comes to

$$P=1-\frac{\xi^2}{6}+\frac{1}{45}\cdot\frac{n}{n+1}\cdot\xi^4+\ldots\ldots\ldots \qquad ..(5)$$

For the solution of (1) in the (u, v) plane, defined as

$$u=-\frac{\xi P^{\frac{2n}{n+1}}}{P'}, \quad v=-\frac{\xi P'}{P}, \qquad ..(6)$$

we have for $n=-1$, the solution is

$$v=c'\,u \qquad ..(7)$$

where c' is the constant of integration. Solving (6) and (7) as simultaneous equations, we get $P^2{}_1=cP^{\frac{3n+1}{n+1}}$.

Substituting the values of P_1 and P from (5) and by simplifying, and keeping terms upto, ξ^2 we have

$$\xi^2=\frac{18c'\,(n+1)}{n\,(2+9c')+2+3c'}$$

giving the value of ξ for the interfacial region.

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REFERENCES

1. Chandrashekhar, S. An Introduction of Stellar Structure.
2. Shambhunath; Proceedings of Nat. Acad. of Sci. India, Section A, Vol. XXXVI Pt. IV, 1966, pp. 909-915.

STEADY FLOW IN A UNIFORM STRAIGHT TUBE

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ABSTRACT

The steady flow of an incompressible viscous fluid in a long uniform tube due to a constant pressure gradient has been considered in this paper. In the first part the section of the tube is a curvilinear triangle bounded by the arc of a cardioid, arc of a parabola and the axis of the cardioid. The exact solution for the velocity has been obtained with the help of finite Fourier transform. In the second part by taking the section of the tube to be semi-cardioid the flow, flux and the drag have also been calculated and lastly in the third part maximum velocity for the semi-cardioid pipe has been computed by the Newton-Raphson Method [4]. Flux and max. velocity have been compared with those obtained in the case of a circular pipe, having the same sectional area.

INTRODUCTION

Steady Flow through straight narrow tubes has been studied by many investigators beginning from POISEULLIE. The present author studied Steady Flow through narrow straight tubes due to a constant pressure gradient, the section of the tube being the curvilinear quadrilateral bounded by (i) arcs of two confocal ellipses and two confocal hyperbolas [6] (ii) four parabolic arcs[7].

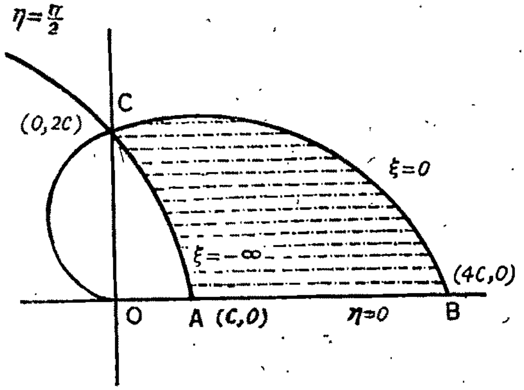

FIG. 1.

In the present paper the author has studied steady flow due to a constant pressure gradient when the section of the tube is the curvilinear triangle A B C shown in figure 1.

Part I

EQUATION OF MOTION

The equation of motion for parallel steady flow in cartesian coordinates is,

$$\nu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}\right)=\frac{1}{\rho}\frac{\partial p}{\partial z} \qquad ..(1)$$

where w is the velocity in the direction of z, other components of velocity are assumed to be zero, ν is the kinematic viscosity and $\frac{\partial p}{\partial z}$ is constant.

Let us introduce the transformation,

$$z=c\,(1+e^{\zeta})^2 \qquad ..(2)$$

$$\text{where } z=x+iy=r\,e^{i\theta} \text{ and } \zeta=\xi+i\eta$$

$$\text{so that } r=c\,(1+2\,e^{\xi}\cos\eta+e^{2\xi})$$

$$\text{and } \tan\frac{\theta}{2}=\frac{e^{\xi}\sin\eta}{1+e^{\xi}\cos\eta}, \text{ (c being a positive constant)}$$

Whence $\eta=0$ is the part of the real axis, extending from $(c, 0)$ to infinity, $\eta=\frac{\pi}{2}$ is the upper half of the parabola $\frac{2c}{r}=(1+\cos\theta)$, $\xi=0$ is the cardioid $r=2c\,(1+\cos\theta)$, $\xi=-\infty$, is the point $(c, 0)$.

Equation of motion with the help of (2) becomes,

$$\frac{\partial^2 w}{\partial\xi^2}+\frac{\partial^2 w}{\partial\eta^2}=-\frac{P}{\nu\rho h^2} \text{ where $-P$ is the value of } \frac{\partial p}{\partial z} \text{ and } h=\left|\frac{d\zeta}{dz}\right|$$

$$=-\frac{P}{\nu\rho}\,4c^2\,e^{2\xi}\,(1+2\,e^{\xi}\cos\eta+e^{2\xi})$$

$$=\lambda\,e^{2\xi}(1+2\,e^{\xi}\cos\eta+e^{2\xi}) \qquad ..(3)$$

where λ is constant and equal to $-\frac{4c^2P}{\nu\rho}$.

The boundary conditions are,

$$\left.\begin{array}{ll} & w=0 \text{ when } \xi=0 \text{ and } \xi=-\infty \\ \text{and} & w=0 \text{ when } \eta=0 \text{ and } \eta=\frac{\pi}{2} \end{array}\right\} \qquad ..(4)$$

Solution of the Equation

Putting, $\eta=\frac{1}{2}q$, equation (3) becomes,

$$\frac{\partial^2 w}{\partial\xi^2}+4\frac{\partial^2 w}{\partial q^2}=\lambda\,e^{2\xi}\,(1+2\,e^{\xi}\cos\tfrac{1}{2}q+e^{2\xi}) \qquad ..(5)$$

subject to the conditions,

$$w=0 \text{ when } \xi=0 \text{ and } \xi=-\infty \text{ and } 0\leqslant q\leqslant\pi \qquad ..(6)$$

$$\text{and } \quad w=0 \text{ when } q=0 \text{ and } q=\pi \text{ and } -\infty\leqslant\xi\leqslant 0 \qquad ..(7)$$

Now we use a Fourier Sine Transform and write $\overline{w}(s)=\int_0^{\pi} w\sin sq\,dq$, where s is a positive integer.

Since w vanishes at $q=0$ and $q=\pi$, $\int_0^{\pi}\frac{\partial^2 w}{\partial q^2}\sin sq\,dq=-s^2\,\overline{w}$.

Applying this transform to the equation (5), we get,

$$\frac{d^2\bar{w}}{d\xi^2} - 4s^2\bar{w} = \lambda\int_0^\pi e^{2\xi}(1+2e^{\xi}\cos\tfrac{1}{2}q+e^{2\xi})\sin sq\,dq$$

$$= \frac{8\lambda s}{4s^2-1}e^{3\xi}\text{, when } s \text{ is even} \qquad ..(8)$$

and $$= \frac{2\lambda}{s}(1+e^{2\xi})\,e^{2\xi} + \frac{8\lambda s\,e^{3\xi}}{4s^2-1} \text{ when } s \text{ is odd} \qquad ..(9)$$

with conditions,

$$\bar{w}=0 \text{ when } \xi=-\infty,\ \xi=0 \qquad ..(10)$$

For even values of s, the solution of the equation (8) is

$$\bar{w} = c_1 e^{2s\xi} + c_2 e^{-2s\xi} - \frac{8\lambda s}{(4s^2-1)(4s^2-9)}e^{3\xi}$$

where c_1 and c_2 are to be determined with the help of conditions (10).

$$\therefore \quad c_2=0$$

$$c_1+c_2=\frac{8\lambda s}{(4s^2-1)(4s^2-9)}$$

Thus $$\bar{w} = \frac{8\lambda s}{(4s^2-1)(4s^2-9)}\left[e^{2s\xi} - e^{3\xi}\right]\text{, where } s \text{ is even.}$$

For odd values of s the solution of equation (9) is,

$$\bar{w} = c_3 e^{2s\xi} + c_4 e^{-2s\xi} - \frac{\lambda e^{2\xi}}{2s(s^2-1)} - \frac{\lambda e^{4\xi}}{2s(s^2-4)} - \frac{8\lambda s e^{3\xi}}{(4s^2-1)(4s^2-9)}$$

The constants c_3 and c_4 are to be determined with the help of conditions (10)

$$\therefore \quad c_4=0$$

and $$c_3+c_4=\frac{\lambda}{2s\,(s^2-1)}+\frac{\lambda}{2s\,(s^2-4)}+\frac{8\lambda s}{(4s^2-1)(4s^2-9)}$$

Thus $$\bar{w} = \left\{\frac{\lambda}{2s\,(s^2-1)}+\frac{\lambda}{2s\,(s^2-4)}+\frac{8\lambda s}{(4s^2-1)(4s^2-9)}\right\}e^{2s\xi}$$

$$-\frac{\lambda e^{2\xi}}{2s\,(s^2-1)}-\frac{\lambda e^{4\xi}}{2s\,(s^2-4)}-\frac{8\lambda s\,e^{3\xi}}{(4s^2-1)(4s^2-9)}\text{, where } s \text{ is odd.}$$

Now by the inversion of the transform,

$$w=\frac{2}{\pi}\sum_s \bar{w}\sin sq\text{, where } s \text{ is a positive integer,}$$

$$=w_1+w_2,$$

where $$w_1=\frac{16\lambda}{\pi}\sum\frac{s}{(4s^2-1)(4s^2-9)}(e^{2s\xi}-e^{3\xi})\sin sq\text{, where } s \text{ is even} \qquad ..(11)$$

and
$$w_2=\frac{2\lambda}{\pi}\Sigma\left[\left\{\frac{\lambda}{2s\,(s^2-1)}+\frac{\lambda}{2s\,(s^2-4)}+\frac{8\lambda s}{(4s^2-1)(4s^2-9)}\right\}e^{2s\xi}\right.$$
$$\left.-\frac{\lambda\, e^{2\xi}}{2s(s^2-1)}-\frac{\lambda\, e^{4\xi}}{2s\,(s^2-4)}-\frac{8\lambda s\, e^{3\xi}}{(4s^2-1)(4s^2-9)}\right]\sin sq,\text{ when } s \text{ is odd} \quad ..(12)$$

Part II

Now let us consider the case of semi-cardioid.

Then the transformed equation

$$\frac{\partial^2 w}{\partial \xi^2}+\frac{\partial^2 w}{\partial \eta^2}=\lambda.e^{2\xi}(1+2\,e^{\xi}\cos\eta+e^{2\xi})$$

is to be solved, subject to the conditions,

$w=0$ when $\eta=0$, $\quad \eta=\pi$, $-\infty\leqslant\xi\leqslant 0$
$w=0$ when $\xi=-\infty$, $\xi=0$, $\quad 0\leqslant\eta\leqslant\pi$

Applying the sine transform to above equation we get,

$$\frac{d^2\bar{w}}{d\xi^2}-s^2\bar{w}=\lambda\, e^{2\xi}\left[(1+e^{2\xi})\times\left(-\frac{\cos s\eta}{s}\right)-e^{\xi}\left\{\frac{\cos(s+1)\eta}{s+1}+\frac{\cos(s-1)\eta}{s-1}\right\}\right]_0^{\pi}$$

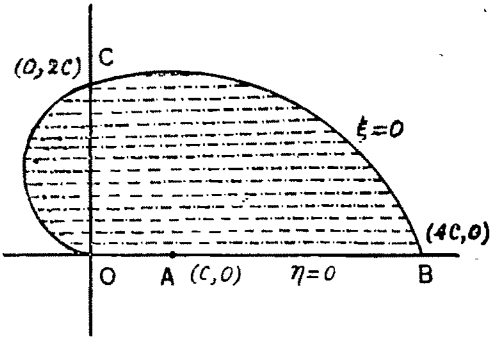

Fig. 2.

R.H.S. of this equation $=\frac{2\lambda\, e^{2\xi}}{s}(1+e^{2\xi})$ when s is odd,

$=\frac{4\lambda s\, e^{3\xi}}{s^2-1}$, when s is even.

$\therefore \quad \bar{w}=c_1 e^{s\xi}+c_2 e^{-s\xi}-\frac{4\lambda s\, e^{3\xi}}{(s^2-1)(s^2-9)}$, when s is even

and $\quad \bar{w}=c_3 e^{s\xi}+c_4 e^{-s\xi}+\frac{2\lambda}{s}\left[\frac{e^{2\xi}}{4-s^2}+\frac{e^{4\xi}}{16-s^2}\right]$, when s is odd.

Applying the boundary conditions

$c_1=\frac{4\lambda s}{(s^2-1)(s^2-9)}$ and $c_2=0$ when s is even.

$\therefore \quad \bar{w}=\frac{4\lambda s}{(s^2-1)(s^2-9)}e^{s\xi}-\frac{4\lambda s\, e^{3\xi}}{(s^2-1)(s^2-9)}$ when s is even,

and $\quad c_4=0,\ c_3=-\frac{2\lambda}{s}\left[\frac{1}{4-s^2}+\frac{1}{16-s^2}\right]$, when s is odd.

$\therefore \quad \bar{w}=-\frac{2\lambda}{s}\left(\frac{1}{4-s^2}+\frac{1}{16-s^2}\right)e^{s\xi}+\frac{2\lambda}{s}\frac{e^{2\xi}}{4-s^2}+\frac{2\lambda}{s}\frac{e^{4\xi}}{16-s^2}$ when s is odd.

Now by inversion of the transform, we get,

$$w=\frac{2}{\pi}\Sigma\ \bar{w}\sin sq$$

$$=w_1+w_2 \quad \text{where}$$

$$w_1=\frac{8\lambda}{\pi}\Sigma\ \frac{s}{(s^2-1)(s^2-9)}\left(e^{s\xi}-e^{3\xi}\right)\sin sq \qquad \text{where } s \text{ is even,} \quad ..(13)$$

$$w_2=\frac{4\lambda}{\pi}\Sigma\left[\frac{1}{s}\cdot\frac{e^{2\xi}}{4-s^2}+\frac{1}{s}\,\frac{e^{4\xi}}{16-s^2}-\frac{1}{s}\left\{\frac{1}{4-s^2}+\frac{1}{16-s^2}\right\}e^{s\xi}\right]\sin s\eta$$

$$\text{where } s \text{ is odd.} \quad ..(14)$$

(ii) Let drag per unit length be D′+D″ where D′ is the drag due to portion BCO and D″ due to OB.

$$\therefore \qquad D'=\int\mu\frac{\partial w}{\partial\eta}ds, \qquad ds \text{ being the length of the arc.}$$

$$=\int_0^\pi\mu\cdot\frac{\partial w}{\partial\xi}d\eta$$

$$=\int_0^\pi\mu\left(\frac{\partial w_1}{\partial\xi}+\frac{\partial w_2}{\partial\xi}\right)d\eta \quad \text{at } \xi=0$$

$$=D_1+D_2 \quad \text{where}$$

$$D_1=\mu\int_0^\pi\left(\frac{\partial w_1}{\partial\xi}\right)_{\xi=0}d\eta=\frac{16\lambda\mu}{\pi}\Sigma\ \frac{s-3}{(s^2-1)\,(s^2-9)} \quad \text{when } s \text{ is even,} \qquad ..(15)$$

and
$$D_2=\mu\int_0^\pi\left(\frac{\partial w_2}{\partial\xi}\right)_{\xi=0}d\eta=\frac{8\lambda\mu}{\pi}\Sigma\left[\frac{2-s}{4-s^2}+\frac{4-s}{16-s^2}\right]\text{when } s \text{ is odd.} \quad ..(16)$$

$$D''=D_3+D_4, \text{ where}$$

$$D_3=\int_0^{-\infty}\mu\frac{\partial w}{\partial\eta}d\xi \qquad \text{along O A where } \eta=\pi$$

$$=\int_0^{-\infty}\mu\left(\frac{\partial w_1}{\partial\eta}+\frac{\partial w_2}{\partial\eta}\right)d\xi \qquad \text{on } \eta=\pi$$

$$=\int_0^{-\infty}\mu\left(\frac{\partial w_1}{\partial\eta}\right)_{\eta=\pi}d\xi+\int_0^{-\infty}\mu\left(\frac{\partial w_2}{\partial\eta}\right)_{\eta=\pi}d\xi$$

$$=\frac{8\lambda\mu}{3\pi}\Sigma\ \frac{s_1\,(s_1-3)}{(s_1{}^2-1)\,(s_1{}^2-9)}-\frac{\lambda\mu}{\pi}\Sigma\ \frac{16-s_2{}^2+4-s_2{}^2-2s_2(16-s_2{}^2)-s_2(4-s_2{}^2)}{s_2\,(4-s_2{}^2)(16-s_2{}^2)} \quad ..(17)$$

where s_1 is even and s_2 is odd,

and
$$D_4=\int_{-\infty}^{0}\mu\frac{\partial w}{\partial\eta}d\xi \qquad \text{along AB where } \eta=0$$

$$=\int_{-\infty}^{0} \mu\left(\frac{\partial w_1}{\partial \eta}+\frac{\partial w_2}{\partial \eta}\right) d\xi$$

$$=\frac{8\lambda\mu}{\pi}\int_{-\infty}^{0} \Sigma \frac{s_1^2}{(s_1^2-1)(s_1^2-9)} \left(e^{s_1\xi}-e^{3\xi}\right) \cos s_1\eta \, d\xi$$

$$+\frac{4\lambda\mu}{\pi}\int_{-\infty}^{0} \Sigma\left[\frac{e^{2\xi}}{4-s_2^2}+\frac{e^{4\xi}}{16-s_2^2}-\left\{\frac{1}{4-s_2^2}+\frac{1}{16-s_2^2}\right\} e^{s_2\xi}\right]\cos s_2\eta d\xi$$

$$=\frac{8\lambda\mu}{\pi} \Sigma\frac{s_1 (3-s_1)}{(s_1^2-1)(s_1^2-9)}+\frac{\lambda\mu}{\pi}\Sigma \frac{2s_2(16-s_2^2)+s_2(4-s_2^2)-2(10-s_2^2)}{s_2 (4-s_2^2)(16-s_2^2)}$$

where s_1 is even s_2 is odd. ..(18)

From (15), (16), (17) and (18) we get the total drag by adding them.

(iii) Flux $=\int\int w \, dx \, dy$

$$=\int_{-\infty}^{0} \int_{\eta=0}^{\pi} w\frac{\partial (x, y)}{\partial (\xi, \eta)}d\xi \, d\eta$$

$$=\int_{-\infty}^{0} \int_{\eta=0}^{\pi} (w_1+w_2) \frac{\partial (x, y)}{\partial (\xi, \eta)}d\xi \, d\eta=F_1+F_2$$

Here $x+iy=c \, (1+e^{\zeta})^2$

$$=c \, (1+2 e^{\zeta} +e^{2\zeta})$$

$$\therefore \frac{\partial (x, y)}{\partial (\xi, \eta)}=4c^2e^{2\xi} \, (1+2 e^{\xi}\cos \eta+e^{2\xi})$$

$$\therefore F_1=\frac{2}{\pi}\Sigma 4\lambda.\frac{s}{(s^2-1)(s^2-9)}\int_{-\infty}^{0} \int_{\eta=0}^{\pi} 4c^2(e^{s\xi}-e^{3\xi}) e^{2\xi}(1+2 e^{\xi}\cos \eta+e^{2\xi})$$

$\times\sin s\eta \, d\xi \, d\eta$ when s is even,

$$=\frac{64\lambda c^2}{\pi}\Sigma \frac{s^2 (3-s)}{3 (s^2-1)^2 (s^2-9)(s+3)}, \qquad ..(19)$$

$$F_2=\Sigma \frac{4\lambda. 4c^2}{\pi}\int_{-\infty}^{0} \int_{0}^{\pi} e^{2\xi}\left[\frac{1}{s}.\frac{e^{2\xi}}{4-s^2}+\frac{1}{s}\frac{e^{4\xi}}{16-s^2}-\frac{1}{s}\left\{\frac{1}{4-s^2}+\right.\right.$$

$$\left.\left.+\frac{1}{16-s^2}\right\} e^{s\xi}\right] \sin s\eta \, (1+2 e^{\xi}\cos \eta+e^{2\xi})d\xi \, d\eta \qquad \text{when } s \text{ is odd.}$$

$$=\frac{32 \lambda c^2}{\pi} \Sigma\left[\frac{5}{12 s^3 (4-s^2)}+\frac{7}{24 s^2 (16-s^2)}-\frac{4(s+3)(10-s^2)}{s^2 (s+2)(s+4) (4-s^2)(16-s^2)}\right.$$

..(20)

$$\text{Total flux} = F_1 + F_2$$
$$= \frac{32\lambda c^2}{\pi}(\cdot 0718)$$
$$= 2{\cdot}903\,\frac{c^4 P}{\mu}$$

Let us compare this flux with that in the case of a circular pipe having an equal sectional area. Area of the section of the semi-cardioid considered above is $3\pi c^2$.

If a be the radius of the circle of equal sectional area then $\pi a^2 = 3\pi c^2$ or $a = \sqrt{3}\,c$.

From Hydro-dynamics by Ramsey[2] flux in case of the circular pipe of radius $a = \dfrac{P\pi a^4}{8\mu}$.

Hence if $a = \sqrt{3c}$, this flux $= \dfrac{P\pi, 9c^4}{8\mu} = 3{\cdot}54\,\dfrac{c^4 P}{\mu}$.

This result shows that the flux in the case of the semi-cardioid pipe is nearly 80% of that in a circular pipe having an equal sectional area.

Part III

To find the maximum velocity for semi-cardioid section and the point at which it occurs.

As this will involve dealing with infinite series we will have recourse of approximation.

$$w = w_1 + w_2$$
$$= \frac{8\lambda}{\pi}\Sigma\,\frac{s_1}{(s_1^2-1)(s_1^2-9)}\left(e^{s_1\xi} - e^{3\xi}\right)\sin s_1\eta$$
$$+\frac{4\lambda}{\pi}\Sigma\left[\frac{1}{s_2}\cdot\frac{e^{2\xi}}{4-s_2^2} + \frac{1}{s_2}\frac{e^{4\xi}}{16-s_2^2} - \frac{1}{s_2}\left\{\frac{1}{4-s_2^2} + \frac{1}{16-s_2^2}\right\} e^{s_2\xi}\right]\sin s_2\eta$$

where s_1 is even and s_2 is odd.

Put $e^{\xi} = y$. Since ξ lies between $-\infty$ and 0, $y \leqslant 1$.

$$\begin{aligned} w = {} & -\frac{8\lambda}{5\pi}\sin\eta\, y + y^2\left[-\frac{16\lambda}{15\pi}\sin 2\eta + \frac{4\lambda}{3\pi}\sin\eta - \frac{4\lambda}{15\pi}\sin 3\eta\right. \\ & \left. -\frac{4\lambda}{105\pi}\sin 5\eta\right] + y^3\left[\frac{8\pi}{105\pi}\sin 3\eta + \frac{16\lambda}{15\pi}\sin 2\eta - \frac{32\lambda}{105\pi}\sin 4\eta\right] \\ & + y^4\left[\frac{4\lambda}{15\pi}\sin\eta + \frac{4\lambda}{21\pi}\sin 3\eta + \frac{32\lambda}{105\pi}\sin 4\eta - \frac{4\lambda}{45\pi}\sin 5\eta\right] \end{aligned}$$

(Neglecting higher powers of y) ..(20A)

For a fixed value of η, w will be maximum when $\dfrac{\partial w}{\partial y} = 0$

i.e., $-\dfrac{2}{5}\sin\eta - \left(\dfrac{8}{15}\sin 2\eta - \dfrac{2}{3}\sin\eta + \dfrac{2}{15}\sin 3\eta + \dfrac{2}{105}\sin 5\eta\right)y$

$$+\left(\frac{2}{35}\sin 3\eta+\frac{4}{5}\sin 2\eta-\frac{8}{35}\sin 4\eta\right)y^2$$

$$+\left(\frac{4}{15}\sin \eta+\frac{4}{21}\sin 3\eta+\frac{32}{105}\sin 4\eta-\frac{4}{45}\sin 5\eta\right)y^3=0.$$

As a trial value, taking $\eta=99°$ this becomes,

$$760y^3-434y^2+928y-395=0 \quad \text{app.}$$

which gives $y=\cdot 44$ (with the help of Horner's method)

$$\therefore \text{ on } \eta=99° \text{ maximum value of } w=-\frac{4\lambda}{\pi}(\cdot 44\times\cdot 09)=-\frac{\cdot 1584\lambda}{\pi} \quad ..(21)$$

Again, when $\eta=90°$, $\dfrac{\partial w}{\partial y}=0$ gives,

$$12y^3+57y^2-781y+400=0 \quad \text{approximately}$$

which gives $y=\cdot 53$. (by Horner's method)

Then max. value of w for this value of η

$$=-\frac{4\lambda}{\pi}\times(\cdot 53)\times\cdot 198=-\frac{\cdot 41976\lambda}{\pi} \quad ..(22)$$

For $\eta=81°$, $\dfrac{\partial w}{\partial y}=0$ gives,

$$207y^3+63y^2+599y-395=0 \quad \text{approximately}$$

which gives $y=\cdot 63$. (by Horner's method)

$$\text{For } \eta=81°,\ w_{\max}=-\frac{4\lambda}{\pi}\cdot(\cdot 63)(\cdot 185)=-\frac{\cdot 46620\lambda}{\pi} \quad ..(23)$$

Here it may be noted that values of w given by these relations are essentially positive since λ is $-ve$

Now the relations (21), (22) and (23) show that w max. occurs for $\eta<81°$; so let us consider a trial value $\eta=72°$ then $\dfrac{\partial w}{\partial y}=0$ gives

$$1474y^3-6540y^2-3988y+3804=0 \quad \text{approximately}$$

which gives $y=\cdot 54$. (by Horner's method)

$$\text{For } \eta=72°,\ w_{\max}=-\frac{4\lambda}{\pi}(\cdot 54)\ [\cdot 004987-\cdot 063569-\cdot 10773+\cdot 380]$$

$$=-\frac{\cdot 461567\lambda}{\pi} \quad ..(24)$$

Now from relations (21), (22), (23) and (24) it is clear that approx. values for $w_{\max}$ will be in the neighbourhood of $\eta=81°$ and $y=\cdot 63$.

Now let us find out better approximation to values of η and y by Newton-Raphson method.

From equation (20A) for maximum w,

$$\frac{\partial w}{\partial \eta}=-\frac{8\lambda}{5\pi}\cos\eta . y+y^2\Big[-\frac{32\lambda}{15\pi}\cos 2\eta+\frac{4\lambda}{3\pi}\cos\eta-\frac{4\lambda}{5\pi}\cos 3\eta$$

$$-\frac{4\lambda}{21\lambda}\cos 5\eta\Big]+y^3\Big[\frac{8\lambda}{35\pi}\cos 3\eta+\frac{32\lambda}{15\pi}\cos 2\eta-\frac{128\lambda}{105\pi}\cos 4\eta\Big]$$

$$+y^4\Big[\frac{4\lambda}{15\pi}\cos\eta+\frac{4\lambda}{7\pi}\cos 3\eta+\frac{128\lambda}{105\pi}\cos 4\eta-\frac{4\lambda}{9\pi}\cos 5\eta\Big]=0 \quad ..(26)$$

and $$\frac{\partial w}{\partial y}=\frac{4\lambda}{\pi}\Big[-\frac{2}{5}\sin\eta-\Big(\frac{8}{15}\sin 2\eta-\frac{2}{3}\sin\eta+\frac{2}{15}\sin 3\eta+\frac{2}{105}\sin 5\eta\Big)y$$

$$+\Big(\frac{2}{35}\sin 3\eta+\frac{4}{5}\sin 2\eta-\frac{8}{35}\sin 4\eta\Big)y^2$$

$$+\Big(\frac{4}{15}\sin\eta+\frac{4}{21}\sin 3\eta+\frac{32}{105}\sin 4\eta-\frac{4}{45}\sin 5\eta\Big)y^3\Big]=0 \quad ..(27)$$

If we denote $\frac{\partial w}{\partial \eta}$ by $\phi\ (\eta, y)$ and $\frac{\partial w}{\partial y}$ by $\psi(\eta, y)$

then,

$$\frac{\partial \phi}{\partial \eta}=\frac{2}{5}\sin\eta\, y+y^2\Big[\frac{16}{15}\sin 2\eta-\frac{1}{3}\sin\eta+\frac{3}{5}\sin 3\eta+\frac{5}{21}\sin 5\eta\Big]$$

$$+y^3\Big[-\frac{6}{35}\sin 3\eta-\frac{16}{15}\sin 2\eta+\frac{128}{105}\sin 4\eta\Big]$$

$$+y^4\Big[-\frac{1}{15}\sin\eta-\frac{3}{7}\sin 3\eta-\frac{128}{105}\sin 4\eta+\frac{5}{9}\sin 5\eta\Big] \quad ..(28)$$

$$\frac{\partial \phi}{\partial y}=-\frac{2}{3}\cos\eta+y\Big[-\frac{16}{15}\cos 2\eta+\frac{2}{3}\cos\eta-\frac{2}{5}\cos 3\eta-\frac{2}{21}\cos 5\eta\Big]$$

$$+y^2\Big[\frac{6}{35}\cos 3\eta+\frac{24}{15}\cos 2\eta-\frac{96}{105}\cos 4\eta\Big]+y^3\Big[\frac{4}{15}\cos\eta$$

$$+\frac{4}{7}\cos 3\eta+\frac{128}{105}\cos 4\eta-\frac{4}{9}\cos 5\eta\Big] \quad ..(29)$$

$$\frac{\partial \psi}{\partial \eta}=-\frac{2}{5}\cos\eta-\Big(\frac{16}{15}\cos 2\eta-\frac{2}{3}\cos\eta+\frac{2}{5}\cos 3\eta+\frac{2}{21}\cos 5\eta\Big)y$$

$$+\Big(\frac{6}{35}\cos 3\eta+\frac{8}{5}\cos 2\eta-\frac{32}{35}\cos 4\eta\Big)y^2+\Big(\frac{4}{15}\cos\eta+\frac{4}{7}\cos 3\eta$$

$$+\frac{128}{105}\cos 4\eta-\frac{4}{9}\cos 5\eta\Big)y^3 \quad ..(30)$$

and $$\frac{\partial \psi}{\partial y}=-\Big(\frac{8}{15}\sin 2\eta-\frac{2}{3}\sin\eta+\frac{2}{15}\sin 3\eta+\frac{2}{105}\sin 5\eta\Big)$$

$$+y\left(\frac{4}{35}\sin 3\eta+\frac{8}{5}\sin 2\eta-\frac{16}{35}\sin 4\eta\right)$$

$$+y^2\left(\frac{4}{5}\sin\eta+\frac{4}{7}\sin 3\eta+\frac{32}{35}\sin 4\eta-\frac{4}{15}\sin 5\eta\right) \qquad ..(31)$$

Taking $\eta_0=81°$ and $y_0=\cdot 63$

$$\psi(\eta_0, y_0)=\cdot 166, \quad \phi(\eta_0, y_0)=-\cdot 0075$$

$$\left(\frac{\partial\phi}{\partial\eta}\right)_0=\cdot 0029, \quad \left(\frac{\partial\phi}{\partial y}\right)_0=-\cdot 685$$

$$\left(\frac{\partial\psi}{\partial\eta}\right)_0=-\cdot 397, \quad \left(\frac{\partial\psi}{\partial y}\right)_0=1\cdot 497$$

If h_1 and k_1 are the corrections then by Newton-Raphson method[5]

$$h_1=\frac{\begin{vmatrix}-\phi(\eta_0, y_0) & \left(\frac{\partial\phi}{\partial y}\right)_0\\ -\psi(\eta_0, y_0) & \left(\frac{\partial\psi}{\partial y}\right)_0\end{vmatrix}}{D}, \quad k_1=\frac{\begin{vmatrix}\left(\frac{\partial\phi}{\partial\eta}\right)_0 & -\phi(\eta_0, y_0)\\ \left(\frac{\partial\psi}{\partial\eta}\right)_0 & -\psi(\eta_0, y_0)\end{vmatrix}}{D},$$

where $$D=\begin{vmatrix}\left(\frac{\partial\phi}{\partial\eta}\right)_0 & \left(\frac{\partial\phi}{\partial y}\right)\\ \left(\frac{\partial\psi}{\partial\eta}\right)_0 & \left(\frac{\partial\psi}{\partial y}\right)_0\end{vmatrix}$$

$$\therefore \quad h_1=\cdot 36, \quad k_1=-\cdot 009$$

$$\therefore \quad \eta_1=\eta_0+h_1=81\cdot 36°, \quad y_1=y_0+k_1$$
$$=\cdot 63-\cdot 009=\cdot 62$$

Now again repeating the same process we get,

$$h_2=\cdot 03, \quad k_2=-\cdot 001$$

Therefore we can take $\eta=81\cdot 4°$ and $y=\cdot 62$ for maximum velocity.

$$\therefore w_{\max}=\frac{4\lambda}{\pi}\left[-\cdot 1103\right]=\frac{1\cdot 7648\, c^2 P}{\pi\rho\nu}$$

$$=\frac{\cdot 5615\, c^2 P}{\mu} \text{ where } \rho\nu=\mu$$

Let us compare this max. velocity with the max. velocity in the case of a circular pipe having an equal sectional area. From Hydro-dynamics by Ramsey[3] max. velocity in case of the circle of radius $a=\frac{Pa^2}{4\mu}$. Hence if $a=\sqrt{3}\,c$, the max. velocity $=\frac{3}{4}\,\frac{c^2P}{\mu}=\frac{\cdot 75\, c^2P}{\mu}$.

This result shows that the max. velocity in the case of the semi-cardioid pipe is 72% of that of the circular pipe having a section equal in area. J. N. Kapur and R. R. Dixit[1] have investigated the max. velocity and flux in the case of slotted tube formed by equal circles. Their findings are:—

Max. velocity = 68·75% of that of the circular pipe of an equal sectional area.
Flux = 66·8% of that of the circular pipe of an equal sectional area.

Thus the pipe considered here is much efficient than the pipe considered by them.

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REFERENCES

1. Kapoor, J. N. & Dikshit, R.R. 1965. *Ganita* **16** (1): 59-64.
2. Ramsey, A. S. *A Treatise on Hydro-mechanics Part II* (Hydro-dynamics), p. 383.
3. *Ibid.*
4. Scarborough, J. B. 1947. *Numerical Mathematical Analysis* (6th printing) p. 187.
5. *Ibid.*, p. 188.
6. Sharma, G. C. 1966. *Agra Univ. J. Res.* (*Sci*) **XV** (1): 59-66.
7. *Ibid.*, **XV** (3): 131-136.

FLOW WITH SUCTION ALONG SOME SURFACES

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INTRODUCTION

Stuart[2] has discussed the motion of incompressible fluids with suction along corners and the outside of circular cylinder. In this paper, flows with suction will be discussed in three different cases namely, (1) along the outside of an elliptic cylinder (2) flat walls with semi elliptic projections, and (3) the out side of a triangular prism with particular case of an equilateral triangular prism, all these surfaces being of infinite length. The fluid is a viscous and incompressible one.

Let x, y, z be the cartesian coordinates with velocity components (u, v, w), z denoting the coordinate parallel to the axis of the cylinder, t denoting time. Since the cylinders are extending from infinity to infinity, the flow may be taken independent of z. Therefore, the equations of motion are,

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\nabla^2 u \qquad ..(1)$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\nu\nabla^2 v \qquad ..(2)$$

$$\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+\nu\nabla^2 w \qquad ..(3)$$

The equation of continuity being,

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \qquad ..(4)$$

We shall now discuss the general principles of such flows after the manner of Stuart[2], u and v may be taken, in special cases to be the velocity components derived from some potential functions $\phi(x, y, t)$. Thus, taking $u=-\frac{\partial\phi}{\partial x}$, $v=-\frac{\partial\phi}{\partial y}$, $\nabla^2\phi=0$, and substituting in the equations (1), (2) and (3) the value of p may be derived as follows :—

$$-\frac{\partial^2\phi}{\partial t\,\partial x}+\frac{\partial\phi}{\partial x}\cdot\frac{\partial^2\phi}{\partial x^2}+\frac{\partial\phi}{\partial y}\cdot\frac{\partial^2\phi}{\partial x\,\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x} \qquad ..(5)$$

$$-\frac{\partial^2\phi}{\partial t\,\partial y}+\frac{\partial\phi}{\partial x}\cdot\frac{\partial^2\phi}{\partial x\partial y}+\frac{\partial\phi}{\partial y}\cdot\frac{\partial^2\phi}{\partial y^2}=-\frac{1}{\rho}\frac{\partial p}{\partial y} \qquad ..(6)$$

And,

$$\frac{\partial w}{\partial t}-\frac{\partial\phi}{\partial x}\cdot\frac{\partial w}{\partial x}-\frac{\partial w}{\partial y}\cdot\frac{\partial\phi}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+\nu\nabla^2 w \qquad ..(7)$$

From equations (5) and (6) we get by integration

$$\frac{p}{\rho}=\phi_t-\tfrac{1}{2}(\phi_x^2+\phi_y^2)+F(t, z) \qquad ..(8)$$

From equation (7) we notice that $\frac{\partial p}{\partial z}$ is free from z, therefore from eqn. (8) $\frac{\partial p}{\partial z}$ must be a function of t alone.

Therefore, (8) gives, $$\frac{p}{\rho} = \phi_t - \tfrac{1}{2}(\phi_x{}^2 + \phi_y{}^2) + zf(t) \qquad \ldots(9)$$

where $f(t)$ is a function of time, the suffixes denoting partial differential coefficients. Therefore, substituting in (7) we get

$$w_t - \phi_x . w_x - \phi_y . w_y = -f(t) + \nu\nabla^2 w \qquad \ldots(10)$$

When the motion is steady, $f(t)=0$ and, the solution of (10) is,

$$w = A + B\, e^{-\frac{\phi}{\nu}} \qquad \ldots(11)$$

where A and B are constants.
A suitable form of equation (11) is

$$\frac{w}{W_0} = 1 - e^{-\frac{\phi}{\nu}} \qquad \ldots(12)$$

Where W_0 is the external stream parallel to the axis of the cylinder. Now, if we take an infinite solid cylinder situated in the fluid in such a way that its axis lies along the axis of z, then, the boundary conditions should be

(*i*) $w=0$, on the surface of the cylinder

(*ii*) $w=W_0$, at infinite distance from the surface of the cylinder.

And, $\frac{\partial \phi}{\partial n}$, if non zero, would be the velocity of suction on the surface of the cylinder.

Case I. *Flow along the outside of an elliptic cylinder :—*

By the Transformation,

$$x + iy = c \cosh \zeta \qquad \ldots(13)$$

$\xi = \xi_0$ corresponds to the ellipse

$$\frac{x^2}{c^2 \cosh^2 \xi_0} + \frac{y^2}{c^2 \sinh^2 \xi_0} = 1$$

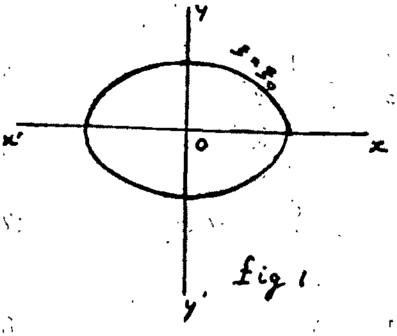

fig 1

If the undisturbed velocity of stream flowing outside this elliptic cylinder, parallel to its axis is W_0. Then,

$$w=0, \text{ on } \xi=\xi_0$$
$$w=W_0, \; \xi \to \infty$$

From (12) we see, that w will satisfy these conditions, if

$$\phi=0, \text{ on } \xi=\xi_0, \; 0 \leqslant \eta \leqslant 2\pi$$
$$\text{and} \quad \phi=\infty, \; \xi \to \infty, \; 0 \leqslant \eta \leqslant 2\pi$$

Therefore, a value of ϕ suitable for this case would be

$$\phi=\beta\ (\xi-\xi_0), \text{ where } \beta \text{ is positive.}$$

so that the equation (12) becomes

$$\frac{w}{W_0}=1-e^{-\frac{\beta}{\nu}(\xi-\xi_0)} \qquad ..(14)$$

Suction Velocity—The suction velocity is perpendicular to the surface and so it is equal to $\left(-h\dfrac{\partial\phi}{\partial\xi}\right)$ on the surface[1] where h is equal to $\left|\dfrac{d\zeta}{dz}\right|$

Now, $-h\dfrac{\partial\phi}{\partial\xi}=-\dfrac{\beta}{c\sqrt{(\sinh^2\xi+\sin^2\eta)}}$, on the surface,

$$=-\frac{\beta}{c\sqrt{(\sinh^2\xi_0+\sin^2\eta)}} \qquad ..(15)$$

Skin Friction—The skin friction at a point of the surface of the cylinder is $\mu\left(h\dfrac{\partial w}{\partial\xi}\right)$

$$=\frac{\mu W_0\beta}{\nu c\sqrt{(\sinh^2\xi_0+\sin^2\eta)}} \qquad ..(16)$$

Therefore, the drag per unit length of the cylinder

$$=\int\frac{\mu W_0\beta}{\nu c\sqrt{(\sinh^2\xi_0+\sin^2\eta)}}\,ds$$

The integral being taken over the boundary of the ellipse, ds being an element of arc of the ellipse.

Now, we will express ds in terms of $d\eta$

$$\begin{aligned} ds &= \sqrt{(dx)^2+(dy)^2} \\ &= c\sqrt{\cosh^2\xi_0\sin^2\eta+\sinh^2\xi_0\cos^2\eta}\,d\eta \\ &= c\sqrt{\sin^2\eta+\sinh^2\xi_0}\,d\eta \end{aligned} \qquad ..(17)$$

$$\begin{aligned} \text{Therefore, drag} &=2\int_0^{\pi}\frac{\mu W_0\beta}{\nu}d\eta \\ &=\frac{2\mu W_0\beta\pi}{\nu} \end{aligned} \qquad ..(18)$$

Case II. *Flow along flat walls with semi-elliptic projections*

Part A—From the transformation (13), we get a wall with a semi-elliptic projection as shown in Fig. (2) bounded by

(*i*) $\xi=\xi_0,\ -\dfrac{\pi}{2}\leqslant\eta\leqslant\dfrac{\pi}{2}$

(*ii*) $\eta=-\dfrac{\pi}{2}$

and, (*iii*) $\eta=\dfrac{\pi}{2}$

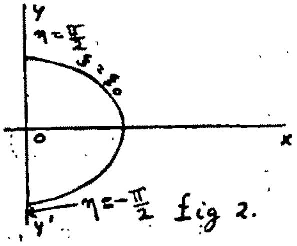

fig 2.

Here, the boundary conditions are the following:

(i) $w=0$, for $\xi=\xi_0$, $-\frac{\pi}{2}\leqslant\eta\leqslant\frac{\pi}{2}$

(ii) $w=0$, for $\eta=-\frac{\pi}{2}$ and $\eta=\frac{\pi}{2}$, $\xi\geqslant\xi_0$

(iii) $w=W_0$, for $\xi\to\infty$, $-\frac{\pi}{2}<\eta<\frac{\pi}{2}$

These conditions lead to

(i) $\phi=0$, $\xi=\xi_0$, $-\frac{\pi}{2}\leqslant\eta\leqslant\frac{\pi}{2}$

(ii) $\phi=0$, $\eta=-\frac{\pi}{2}$ and $\frac{\pi}{2}$, $\xi\geqslant\xi_0$

(iii) $\phi=\infty$, $\xi\to\infty$, $-\frac{\pi}{2}<\eta<\frac{\pi}{2}$

Therefore, a suitable value of ϕ for this case is

$$\phi=\beta\sinh(\xi-\xi_0)\cos\eta$$

And, the equation (12), then, becomes

$$\frac{w}{W_0}=1-e^{-\frac{\beta}{\nu}\sinh(\xi-\xi_0)\cos\eta} \quad ..(19)$$

Suction Velocity—As in the previous case, the suction velocity on the elliptical projection would be $\left(-h\frac{\partial\phi}{\partial\xi}\right)$

$$=-\frac{\beta\cos\eta}{c\sqrt{(\sinh^2\xi_0+\sin^2\eta)}} \quad ...(20)$$

And, the velocity perpendicular to the plane wall would be $\left(-h\frac{\partial\phi}{\partial\eta}\right)$

$$=\frac{\beta\sinh(\xi-\xi_0)\sin\eta}{c\sqrt{(\sinh^2\xi_0+\sin^2\eta)}}, \text{ for particular values of } \eta$$

On the wall, $\eta=-\frac{\pi}{2}$, the velocity $=-\frac{\beta\sinh(\xi-\xi_0)}{c\cosh\xi}$ ..(21)

And on the wall, $\eta=\frac{\pi}{2}$, the velocity$=\frac{\beta\sinh(\xi-\xi_0)}{c\cosh\xi}$ ..(22)

From (21) and (22) we observe that on the plane wall $\eta=\frac{\pi}{2}$, there is injection and on the wall $\eta=-\frac{\pi}{2}$ there is a suction.

Skin Friction—On the elliptic projection, the skin friction is $\mu\left(h\frac{\partial w}{\partial\xi}\right)$

$$=\frac{\mu W_0\beta\cos\eta}{\nu c\sqrt{(\sinh^2\xi_0+\sin^2\eta)}} \qquad ..(23)$$

$$\text{The drag per unit length}=\frac{2\mu W_0\beta}{\nu}\int_0^{\pi/2}\cos\eta\,d\eta$$

$$=\frac{2\mu W_0\,\beta}{\nu} \qquad ..(24)$$

On the plane wall, the skin friction is $\mu\left(h\frac{\partial w}{\partial\eta}\right)$

$$=-\frac{\mu W_0\,\beta\sinh(\xi-\xi_0)\sin\eta}{\nu c\sqrt{(\sinh^2\xi+\sin^2\eta)}}\,e^{-\frac{\beta}{\nu}(\xi-\xi_0)\cos\eta}$$

Therefore, on the wall, $\eta=-\frac{\pi}{2}$, *it is* $=-\frac{\mu W_0\beta\sinh(\xi-\xi_0)}{\nu c\cosh\xi}$ ..(25)

And, on the wall, $\eta=\frac{\pi}{2}$, *it* would be

$$=\frac{\mu W_0\,\beta\sinh(\xi-\xi_0)}{\nu c\cosh\xi} \qquad ..(26)$$

Part B—Again, from the transformation (13), we get a wall with semi-elliptic projection as shown in figure (3) bounded by

(*i*) $\xi=\xi_0,\ 0\leqslant\eta\leqslant\pi$
(*ii*) $\eta=0$
and (*iii*) $\eta=\pi$

The conditions to be satisfied by ϕ are

(*i*) $\phi=0,\ \xi=\xi_0,\ 0\leqslant\eta\leqslant\pi$
(*ii*) $\phi=0,\ \eta=0$ and $\eta=\pi$
(*iii*) $\phi=\infty,\ \xi\to\infty,\ 0<\eta<\pi$.

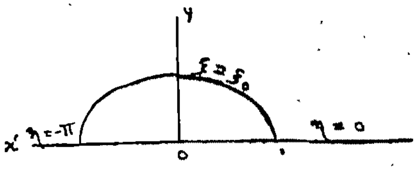

fig 3.

Therefore, ϕ may be taken as

$$\phi=\beta\sinh(\xi-\xi_0)\sin\eta$$

And, the equation (12) becomes

$$\frac{w}{W_0}=1-e^{-\frac{\beta}{\nu}\sinh(\xi-\xi_0)\sin\eta} \qquad ..(27)$$

Suction Velocity—On the elliptic surface, the suction velocity $\left(-h\frac{\partial\phi}{\partial\xi}\right)$ is $-\frac{\beta\sin\eta}{c\sqrt{(\sinh^2\xi_0+\sin^2\eta)}}$ ..(28)

Velocity $\left(-h\frac{\partial\phi}{\partial\eta}\right)$ perpendicular to the plane walls would be

$$=-\frac{\beta\sinh(\xi-\xi_0)\cos\eta}{c\sqrt{(\sinh^2\xi+\sin^2\eta)}},\text{ for the particular values of }\eta$$

Therefore, on the wall $\eta=0$, the velocity $=-\frac{\beta\sinh(\xi-\xi_0)}{c\sinh\xi}$ ..(29)

And, on the wall, $\eta=\pi$, it would be $=\frac{\beta\sinh(\xi-\xi_0)}{c\sinh\xi}$ ..(30)

Hence, again, from (29) on the wall, $\eta=0$, the velocity is a velocity of suction, while from (30), on the wall, $\eta=\pi$, it is a velocity of injection.

Skin Friction—On the elliptic wall, the skin friction is

$$\mu\left(i\frac{\partial w}{\partial\xi}\right)=\frac{\mu W_0\beta\sin\eta}{\nu c\sqrt{(\sinh^2\xi_0+\sin^2\eta)}}$$

The drag per unit length $=\frac{W_0\beta}{\nu}\int_0^\pi\sin\eta\,d\eta$

$$=\frac{2\mu W_0\beta}{\nu} \qquad ..(31)$$

On the plane wall, $\eta=0$, the skin friction

$$=\left\{\frac{\mu W_0\beta e^{-\frac{\beta}{\nu}\sinh(\xi-\xi_0)\sinh\eta}}{\nu c\sqrt{(\sinh^2\xi+\sin^2\eta)}}\sinh(\xi-\xi_0)\cos\eta\right\}$$

$$=\frac{\mu W_0\beta\sinh(\xi-\xi_0)}{\nu c\sinh\xi} \qquad ...(32)$$

And, on the plane wall, $\eta=\pi$, it is equal to

$$=-\frac{\mu W_0\beta\sinh(\xi-\xi_0)}{\nu c\sinh\xi} \qquad ...(33)$$

Case III. *Flow along the outside of a Triangular Prism.*

If the stream W_0 flows in the direction of its axis, along the out side of a triangular prism, then

(*i*) $w=0$, on the plane faces of the prism.

(*ii*) $w=W_0$, at an infinite distance from the faces

These conditions lead to

(*i*) $\phi=0$, on the plane faces of the prism ...(34)

(*ii*) $\phi=\infty$, at infinite distance from the prism.

Therefore, a suitable choice for ϕ would be

$$\phi=\beta\,\{(x+ay+b)(x+cy+d)(x+ey+f)\}$$

where ϕ is to satisfy Laplace's equation and

$$x+ay+b=0 \qquad (i)$$

$$x+cy+d=0 \qquad (ii)$$

$$x+ey+f=0 \qquad (iii)$$

are to form the boundaries of the cross section of the prism

Hence, $\dfrac{\partial^2\phi}{\partial x^2}+\dfrac{\partial^2\phi}{\partial y^2}$

$$=\{(3+ac+ae+ce)x+(e+c+a+3aec)y+(b+d+f+acd+acf+bce)\}$$

$$=0, \text{ identically} \qquad \ldots(35)$$

Therefore,

$$ac+ae+ce+3=0 \qquad (i)$$

$$e+c+a+3aec=0 \qquad (ii)$$

$$b+d+f+acf+aed+bce=0 \qquad (iii) \qquad \ldots(36)$$

We have six arbitrary parameters a, b, c, d, e, f which are connected by three equations only. Hence three parameters are absolutely at our choice. We can, therefore, get infinite number of triangular prisms by choosing a, b, c, etc. so as to satisfy these equations, provided the three lines enclose a triangle for which the condition is

$$\begin{vmatrix} 1 & a & b \\ 1 & c & d \\ 1 & e & f \end{vmatrix} \neq 0$$

or $cf+eb+ad-ed-bc-af\neq 0$ ...(37)

As an illustration, a particular case is given below:—

Taking, $a=1$, $b=-1$, $c=-3$.
$d=2$, $e=-1$, and $f=2$, we have,
$\phi=\beta\{(x+y-1)(x-3y+2)(x-y+2)\}$

This obiously satisfy the conditions (34)

And, the equation (12) becomes

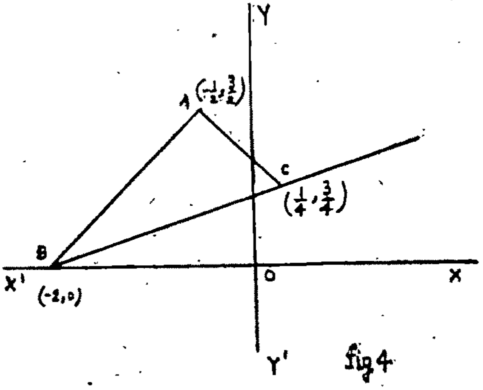

fig 4

$$\frac{w}{W_0}=1-e^{-\frac{\beta}{\nu}\{(x+y-1)(x-3y+2)(x-y+2)\}} \qquad \ldots(38)$$

The section of the prism in xy plane is given in the figure 4, the vertices are the points A $(-\frac{1}{2}, \frac{3}{2})$, B $(-2, 0)$ and C $(\frac{1}{4}, \frac{3}{4})$

Suction and Injection Velocity

Here, $\left(-\frac{\partial\phi}{\partial x}\right)=-\beta\{(x-y+2)(x-3y+2)+(x+y-1)\ (x-y+2)+(x-3y+2)(x+y-1)\}$

$$\left(-\frac{\partial\phi}{\partial y}\right)=-\beta\{(x-3y+2)(x-y+2)-(x+y-1)(x-3y+2)-3(x+y-1)(x-y+2)\}$$

Also, the suction velocity, $\left(-\frac{\partial\phi}{\partial n}\right)=-\left(\frac{\partial\phi}{\partial x}\cdot\frac{\partial x}{\partial n}+\frac{\partial\phi}{\partial y}\cdot\frac{\partial y}{\partial n}\right)$ ..(39)

$\left(\text{where } \frac{\partial x}{\partial n}, \frac{\partial y}{\partial n}, \text{ are d.c.s. of the normal}\right)$

(a) The velocity on the plane $x+y-1=0$

On the plane, $\left(-\frac{\partial\phi}{\partial x}\right)=-\beta\{(x-3y+2)(x-y+2)\}$

$$=-\beta\ (4y-3)(2y-3)$$

$$\left(-\frac{\partial\phi}{\partial y}\right)=-\beta\{(x-3y+2)(x-y+2)\}$$

$$=-\beta\ (4y-3)(2y-3)$$

And, $\frac{\partial x}{\partial n}=\frac{1}{\sqrt{2}}$, $\frac{\partial y}{\partial n}=\frac{1}{\sqrt{2}}$

Therefore, $\left(-\frac{\partial\phi}{\partial n}\right)=-\beta\sqrt{2}\ \{(x-3y+2)(x-y+2)\}$

$$=-\beta\sqrt{2}\ \{(4y-3)(2y-3) \qquad ..(40)$$

Between the points A and C (40) is positive, therefore, there would be an injection on this plane.

(b) The velocity on the plane $x-3y+2=0$

On this plane, $\left(-\frac{\partial\phi}{\partial x}\right)=-\beta\{(x+y-1)(x-y+2)\}$

$$=-\beta.2y\ (4y-3)$$

$$\left(-\frac{\partial\phi}{\partial y}\right)=3\beta\{(x+y-1)(x-y+2)\}$$

$$=3\beta.\ 2y\ (4y-3)$$

And, $\partial n=-\frac{1}{\sqrt{10}}$, $\frac{\partial y}{\partial n}=\frac{3}{\sqrt{10}}$

Therefore, $\left(-\frac{\partial\phi}{\partial n}\right)=\beta\sqrt{10}\ (x+y-1)(x-y+2)$

$$=2\ \beta\sqrt{10}\ .\ y\ (4y-3) \qquad ..(41)$$

Between the points, B and C, (41) is negative, therefore, there would be a suction on this plane.

(c) The velocity on the plane $x-y+2=0$

On this plane,
$$\left(-\frac{\partial\phi}{\partial x}\right)=-\beta\,\{(x-3y+2)(x+y-1)\}$$
$$=2\beta . y\ (2y-3)$$
$$\left(-\frac{\partial\phi}{\partial y}\right)=\beta\{(x+y-1)(x-3y+2)\}$$
$$=-2\beta . y\ (2y-3)$$

And, $\dfrac{\partial x}{\partial n}=-\dfrac{1}{\sqrt{2}},\ \dfrac{\partial y}{\partial n}=\dfrac{1}{\sqrt{2}}$

Therefore,
$$\left(-\frac{\partial\phi}{\partial n}\right)=\beta\sqrt{2}\ \{(x-3y+2)(x+y-1)\}$$
$$=-2\beta\sqrt{2}\cdot y\ (2y-3) \qquad ..(42)$$

Between A and B, (42) is positive, therefore, there would be injection on this plane also.

DRAG ON THE THREE PLANES

The skin friction is p_{nz}

$$=\mu\frac{\partial w}{\partial n}$$
$$=\mu\left\{\frac{\partial w}{\partial x}\cdot\frac{\partial x}{\partial n}+\frac{\partial w}{\partial y}\cdot\frac{\partial y}{\partial n}\right\}$$

Now,
$$\frac{\partial w}{\partial x}=\frac{W_0\beta}{\nu}e^{-\frac{\beta}{\nu}\{(x+y-1)(x-3y+2)(x-y+2)\}}\times\{(x-3y+2)(x-y+2)$$
$$+(x-y+2)(x+y-1)+(x-3y+2)(x+y-1)\} \qquad ...(43)$$

And,
$$\frac{\partial w}{\partial y}=\frac{W_0\beta}{\nu}e^{-\frac{\beta}{\nu}\{(x+y-1)(x-3y+2)(x-y+2)\}}\times\{(x-3y+2)(x-y+2)$$
$$-(x+y-1)(x-3y+2)-3(x+y-1)(x-y+2)\} \qquad ..(44)$$

(d) The skin friction on the plane $x+y-1=0$

On this plane,
$$\left(\frac{\partial w}{\partial x}\right)=\frac{W_0\beta}{\nu}\{(x-3y+2)(x-y+2)\}$$
$$=\frac{W_0\beta}{\nu}(4y-3)(2y-3)$$
$$\left(\frac{\partial w}{\partial y}\right)=\frac{W_0\beta}{\nu}(x-3y+2)(x-y+2)$$
$$=\frac{W_0\beta}{\nu}(4y-3)(2y-3)$$

And, $\dfrac{\partial x}{\partial n}=\dfrac{1}{\sqrt{2}},\ \dfrac{\partial y}{\partial n}=\dfrac{1}{\sqrt{2}}$

Therefore,
$$\left(\mu\frac{\partial w}{\partial n}\right)=\frac{W_0\beta}{\nu}\sqrt{2}\,.\,\mu\{(4y-3)(2y-3)\} \qquad ..(45)$$

Hence, the drag per unit length of the plane $x+y-1=0$

$$=\frac{W_0\beta}{\nu}\cdot\sqrt{2}\cdot\mu\int_{\frac{3}{4}}^{\frac{3}{2}}\sqrt{2}\ (8y^2-18y+9)\,dy$$

$$=-\frac{9}{8}\cdot\frac{W_0\beta\mu}{\nu} \qquad ..(46)$$

(e) The skin friction on the plane $x-3y+2=0$

On this plane, $\left(\frac{\partial w}{\partial x}\right)=\frac{W_0\beta}{\nu}(x+y-1)(x-y+2)$

$$=\frac{2W_0\beta}{\nu}\,y\,(4y-3)$$

$$\left(\frac{\partial w}{\partial y}\right)=-\frac{3W_0\beta}{\nu}(x+y-1)(x-y+2)$$

$$=-\frac{6W_0\beta}{\nu}\cdot y\,(4y-3)$$

Also, $\frac{\partial x}{\partial n}=-\frac{1}{\sqrt{10}},\ \frac{\partial y}{\partial n}=\frac{3}{\sqrt{10}}$

Therefore, $\left(\mu\frac{\partial w}{\partial n}\right)=-\frac{\mu W_0\beta}{\nu}\sqrt{10}\ (x-y+2)(x+y-1)$

$$=-\frac{2W_0\beta\mu\sqrt{10}\cdot y\,(4y-3)}{\nu}$$

Hence, the drag per unit length of the plane $x-3y+2=0$

$$=-\frac{2\,\mu\,W_0\beta}{\nu}\sqrt{10}\int_0^{\frac{3}{4}}(4y^2-3y)\sqrt{10}\ dy$$

$$=\frac{45}{8}\cdot\frac{W_0\beta\mu}{\nu} \qquad ..(47)$$

(f) The skin friction on the plane $x-y+2=0$

On the plane, $\left(\frac{\partial w}{\partial x}\right)=\frac{W_0\beta}{\nu}(x-3y+2)(x+y-1)$

$$=-\frac{2W_0\beta}{\nu}\cdot y\,(2y-3)$$

$$\left(\frac{\partial w}{\partial y}\right)=-\frac{W_0\beta}{\nu}(x-3y+2)(x+y-1)$$

$$=\frac{2W_0\beta}{\nu}\cdot y\,(2y-3)$$

And, $\frac{\partial x}{\partial n}=-\frac{1}{\sqrt{2}},\ \frac{\partial y}{\partial n}=\frac{1}{\sqrt{2}}$

Therefore, $\left(\mu\frac{\partial w}{\partial n}\right)=\frac{2\mu W_0\beta}{\nu}\cdot\sqrt{2}\cdot y\,(2y-3)$

Hence, drag per unit length of the plane $x-y+2=0$

$$=\frac{2\mu W_0\beta}{\nu}\sqrt{2}\int_{\frac{3}{2}}^{0}(2y^2-3y)\ dy$$

$$=\frac{9}{2}\frac{\mu W_0\beta}{\nu} \qquad ..(48)$$

EQUILATERAL TRIANGULAR PRISM

If we take $a=3$, $b=0$, $c=\frac{5\sqrt{3}-6}{13}$, $d=1$, $e=-\frac{5\sqrt{3}+6}{13}$, $f=2+\sqrt{3}$, we get an equilateral triangle in xy plane, of which the vertices are $A\left(-\frac{3(3+\sqrt{3})}{10}, \frac{13(3+\sqrt{3})}{30}\right)$, $B\left(-\frac{9+\sqrt{3}}{10}, \frac{9+\sqrt{3}}{30}\right)$ and $C\left(-\frac{15+7\sqrt{3}}{10}, \frac{15+7\sqrt{3}}{30}\right)$

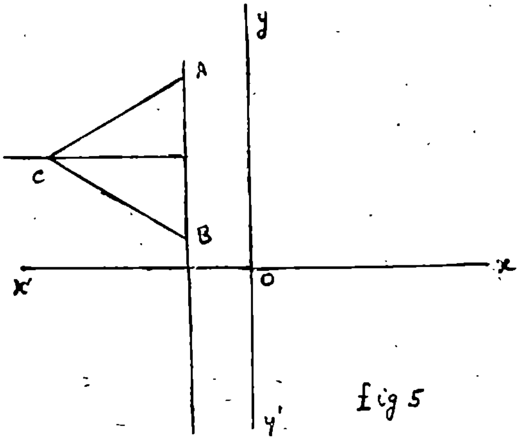

fig 5

This leads to $\phi=\beta\left\{(x+3y)\left(x+\frac{5\sqrt{3}-6}{13}y+1\right)\left(x-\frac{5\sqrt{3}+6}{13}y+2+\sqrt{3}\right)\right\}$

Hence, the equation (12) becomes

$$\frac{w}{W_0}=1-e^{-\frac{\beta}{\nu}\left\{(x+3y)\left(x+\frac{5\sqrt{3}-6}{13}y+1\right)\left(x-\frac{5\sqrt{3}+6}{13}y+2+\sqrt{3}\right)\right\}} \quad ..(49)$$

I am highly grateful to Dr. J. P. Agarwal, Agra College, Agra, for the help and guidance in the preparation of this Paper.

REFERENCES

1. Ramsay, A. S. 1954. *Treatise on Hydrodynamics*, pp. 101-102.
2. Stuart, J. T. *Quarterly G. Jour. of Mech. & Applied Maths.*, **XIX** (II).

REDUCTION OF MERCURIC CHLORIDE BY CITRIC ACID INDUCED BY POTASSIUM PERMANGANATE

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SUMMARY

Reduction of mercuric chloride by citric acid in presence of potassium permanganate as inductor has been studied. A tentative mechanism of the reaction has been suggested.

INTRODUCTION

The oxidation of citric acid by permanganate has been studied by Deniges[3] and Phipson[5]. According to these workers acetone dicarboxylic acid and oxalic acid are the possible intermediates. A kinetic study of the oxidation of citric acid by acid permanganate has been made by Bhagwat, W.V. and coworkers[2] who observed that the reaction was autocatalytic.

Although the oxidation of citric acid by potassium permanganate has been studied by previous workers but the fact remains that the reduction of mercuric chloride by this acid in presence of potassium permanganate as inductor has not been adequately studied. Dhar[4] studied this reaction on the semiquantitative basis. In the present paper we have extended our previous work[1] on the kinetics of reduction of mercuric chloride by citric acid in presence of potassium permanganate as inductor and an attempt has been made to suggest a probable mechanism of the reaction.

EXPERIMENTAL

The experimental procedure for studying the kinetics of the reaction was the same as reported earlier[1].

OBSERVATIONS

Effect of temperature

The kinetics of the reaction was studied at 50 and 60°C to see the influence of temperature. The observations are given in the following table and figure 1.

TABLE 1

Citric acid=0·025 M, $HgCl_2 = KMnO_4 = 0·01$ M

50°C Induction period=1 min.			60°C Induction period=0·5 min.	
Time in min.	Hg_2Cl_2 formed (X) in moles/l$\times 10^3$	dc/dt$\times 10^7$	Hg_2Cl_2 formed (X) in moles/l$\times 10^3$	dc/dt$\times 10^7$
0	...	...	...	...
5	1·65	3300·0	1·80	3600·0
15	1·70	50·0	1·90	83·3
30	1·80	66·6	2·00	66·6

TABLE 1 (*Contd.*)

60	1·90	33·3	2·10	33·3
120	1·925	4·16	2·15	8·33
180	1·95	4·16	2·20	8·33
240	1·975	4·16	2·25	8·33
300	2·00	4·16	2·30	8·33
360	2·025	4·16	2·35	8·33

It is seen from the above table and fig. 1 that the reaction has a small period of induction after which it develops rapidly upto 5 minutes and then its velocity diminishes. The dc/dt values are very high in the beginning and then suddenly fall becoming constant in the later stages of the reaction. These observations lead to the conclusion that the whole course of the reaction consists of three zones viz., (i) period of induction, (ii) auto-catalysis and (iii) auto-inhibition followed by a normal reaction.

It is also observed from Fig. 1 that rise of temperature increases the overall velocity of the reaction and affects its various zones. The temperature coefficient of the reaction during its normal course was found to be 2·0 and the corresponding energy and entropy of activation 14·9 k cals and —42·3 e.u. respectively.

Effect of the initial concentration of the reactants:—

TABLE 2

Temperature 50°C

$HgCl_2$=$KMnO_4$=0·01 M		Citric acid=0·025M $KMnO_4$=0·01M		Citric acid=0·025M $HgCl_2$=0·01M	
Citric acid in moles/l	A*	$HgCl_2$ in moles/l	A*	$KMnO_4$ in moles/l	A*
0·025	1·80	0·005	1·35	0·0025	0·55
0·05	1·40	0·01	2·00	0·005	0.95
0·10	1·15	0·02	2·30	0·0075	1·40
0·15	1·00	0·03	2·575	0·01	2·00
0·20	0·95	0·04	2·875	0·0125	2·20
...	...	...	...	0·015	2·55

A*=Hg_2Cl_2 formed in 60 minutes in moles per litre X 10^3

It is seen from the above table that the reduction of mercuric cloride increases with the initial concentration of mercuric chloride and potassium permanganate but it decreases by increasing the initial concentration of citric acid.

Effect of gases

TABLE 3

Citric acid=0·025 M, $HgCl_2$=$KMnO_4$=0·01 M, Temp.=50°C

Gas	Hg_2Cl_2 formed in 60 mins in moles/l × 10^3
—	1·80
Oxygen	2·30
Carbondioxide	2·10

The above table shows that oxygen and carbondioxide gases exert a catalytic influence on the reduction of mercuric chloride.

Effect of Acids

TABLE 4

(Conditions same as in table 3)

Acid (0·01 N)	Hg_2Cl_2 fromed in 60 mins. in moles/l × 10^3
...	1·80
HCl	1·20
HNO_3	1·50
H_2SO_4	1·60
CH_3COOH	1·80

It is seen from the above table that the reduction of mercuric chloride is retarded in presence of HCl, H_2SO_4 and HNO_3 but remains unaffected in presence of CH_3COOH. The retarding capacity of these acids is in the order $HCl > HNO_3 > H_2SO_4$.

Effect of KCl, K_2SO_4, KNO_3, $MnSO_4$ and CH_3COONa.

TABLE 5

(Conditions same as in table 3.)

Salt in moles/*l*	Hg_2Cl_2 formed in 60 mins. in moles/l × 10^3				
	KCl	K_2SO_4	KNO_3	$MnSO_4$	CH_3COONa
...	1.80	1·80	1.80	1·80	1·80
0·01	1.50	1·65	1.70	1·35	...
0·02	1.25	1·55	1.60	1·15	...
0·04	1.00	1·40	1.35	1·00	2·00
0·06	...	...	...	...	2·15
0·08	...	...	...	...	2·30
0·10	...	...	...	...	2·50

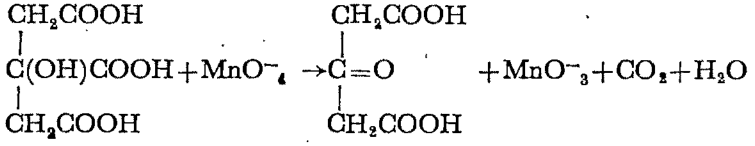
It is seen from the above table that all the salts used, except sodium acetate, have negative effect on the reduction of mercuric chloride. Sodium acetate increases the reduction.

Variations in conductivity

From Fig. 3, it is seen that the conductivity first increases for some time in the beginning and then falls and finally becomes constant.

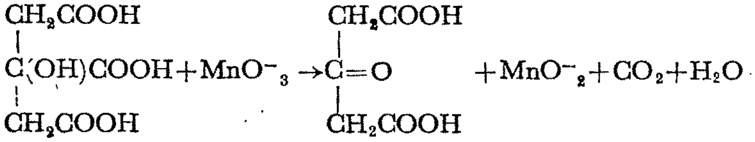
DISCUSSION

Citric acid alone, like other organic acids (oxalic, malonic tartaric etc.) does not reduce mercuric chloride even at high temperature but in the presence of potassium permanganate it does so. This suggests that some active substance is produced as a result of interaction between potassium permanganate and citric acid which reduces mercuric chloride. The nature of this active substance will depend upon the oxidation product of citric acid. The active substance is probably produced after the formation and decomposition of a transient intermediate complex of citric acid with manganic ion. The formation of an intermediate complex and a chan mechanism involving free radical are also evident from the negative values of the entropy of activation. The reaction is governed by a chain mechanism enveloping its various zones. The various steps may be represented as follows :



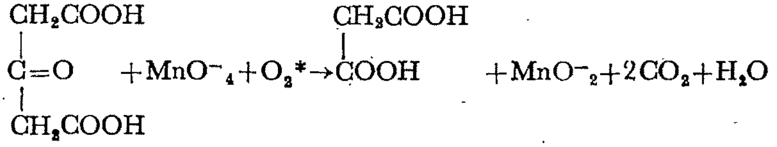
$$\begin{array}{c} CH_2COOH \\ | \\ C(OH)COOH \\ | \\ CH_2COOH \end{array} + MnO^-_4 \rightarrow \begin{array}{c} CH_2COOH \\ | \\ C{=}O \\ | \\ CH_2COOH \end{array} + MnO^-_3 + CO_2 + H_2O$$

..(1)



$$\begin{array}{c} CH_2COOH \\ | \\ C(OH)COOH \\ | \\ CH_2COOH \end{array} + MnO^-_3 \rightarrow \begin{array}{c} CH_2COOH \\ | \\ C{=}O \\ | \\ CH_2COOH \end{array} + MnO^-_2 + CO_2 + H_2O$$

..(2)



$$\underset{\textstyle CH_2COOH}{\overset{\textstyle CH_2COOH}{C=O}} + MnO^-_4 + O_2{}^* \rightarrow \overset{\textstyle CH_2COOH}{COOH} + MnO^-_2 + 2CO_2 + H_2O \quad ..(3)$$

(* O_2 may be produced in the system as a result of disproportion of some of the Mn^{3+} ions produced in steps 2 and 3, into Mn^{4+} ions which react with water forming OH radicals responsible for the production of oxygen as shown below:

$$2Mn^{3+} \rightarrow Mn^{4+} + Mn^{2+}$$
$$Mn^{4+} + H_2O \rightarrow Mn^{3+} + OH + H^+$$
$$OH + OH \rightarrow H_2O + \tfrac{1}{2}O_2$$

The rest of the Mn^{3+} ions may form an intermediate complex with the remaining citrate ions which on its decomposition refurnishes Mn^{3+} ions and other products.

$$\text{Complex} \rightarrow Mn^{3+} + \text{Products} \quad ..(4)$$

These Mn^{3+} ions, formed after the decomposition of the complex, are in an activated state and convert malonic acid (formed in step 3) into oxalic acid through a series of transient intermediates as has been explained in our previous publication (loc. cit.).

$$\text{Malonic} \rightarrow \text{Tartronic} \rightarrow \text{Glyoxalic} \rightarrow \text{Oxalic} \rightarrow C_2O_4{}^{2-} \quad ..(5)\ \text{Fast}$$

The reduction of mercuric chloride is brought about by the CO^-_2 radicals which are produced as a result of interaction of $C_2O_4{}^{2-}$ ions with Mn^{3+} ions as shown below:

$$C_2O_4{}^{2-} + Mn^{3+} \rightarrow CO_2 + CO_2{}^- + Mn^{2+} \quad ..(6)\ \text{Fast}$$
$$CO^-_2 + Hg^{2+} \rightarrow CO_2 + Hg^+ \quad ..(7)$$

The chain breaking step may be the removal of CO^-_2 radical by Mn^{2+} ion :

$$CO^-_2 + Mn^{3+} \rightarrow CO_2 + Mn^{2+} \quad ..(8)$$

Steps 1—6 are included in the induction period and are fast. The autocatalysis in the beginning is due to the accumulation of $CO_2{}^-$ redicals in high concentrations as a result of fast reactions 5 and 6.

The catalytic effect of CO_2 gas may be due to the formation of more $CO_2{}^-$ radicals as a result of interaction of CO_2 molecule with an electron in presence of the reducing acid ($CO_2 + e^- \rightarrow CO_2{}^-$).

Oxygen accelerates the reaction which may be due to the fact that the velocity of the reaction steps 3 and 5 is highly enhanced in presence of oxygen.

The inhibiting effect of $MnSO_4$ may be due to the formation of some manganous citrate complex which reduces the concentration of free citric acid in the reaction mixture.

The conductivity variation can be explained in the light of the above mechanism. The initial rise in conductivity may be due to the formation of more conducting oxidation products of citric acid. The fall in conductivity is due to the formation of manganic citrate complex.

Thanks are due to Dr. L. K. Saxena, Chemistry Department, Agra College, Agra and Dr. A. K. Bhattacharya, Head and Prof. of Chemistry, University of Jummu and Kashmir for their keen interest in the work.

REFERENCES

1. Bansal, O.P. & Mathur, P.C. *J. Ind. Chem. Soc.*, 1965, *42*, 232, 235, 863; 1966, *43*, 215; 375.
2. Bhagwat, W. V. & Coworkers. 1953. *J. Sci. Ind. Res.* (India), **123**, 521
3. Deniges. 1900. *Comt. Rend.* **130**, 22.
4. Dhar 1917. *J. Chem. Soc.* **111**, 69
5. Phipson 1862. *J. Chem. Soc.* **15**, 142

Fig 1

Effect of temperature on the reduction of mercuric chloride by Citric acid induced by potassium permanganate.

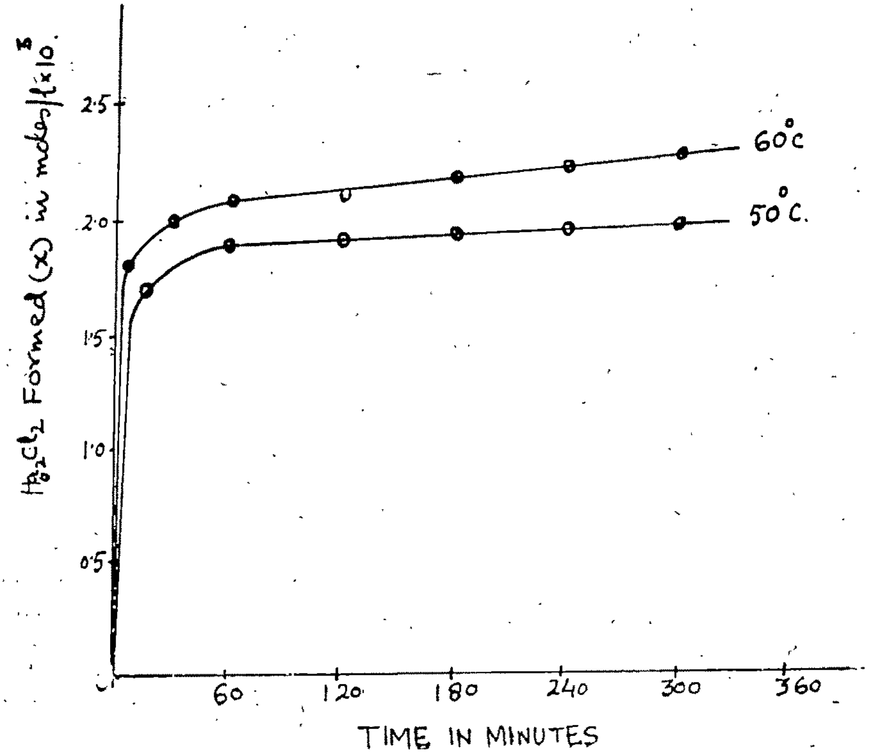
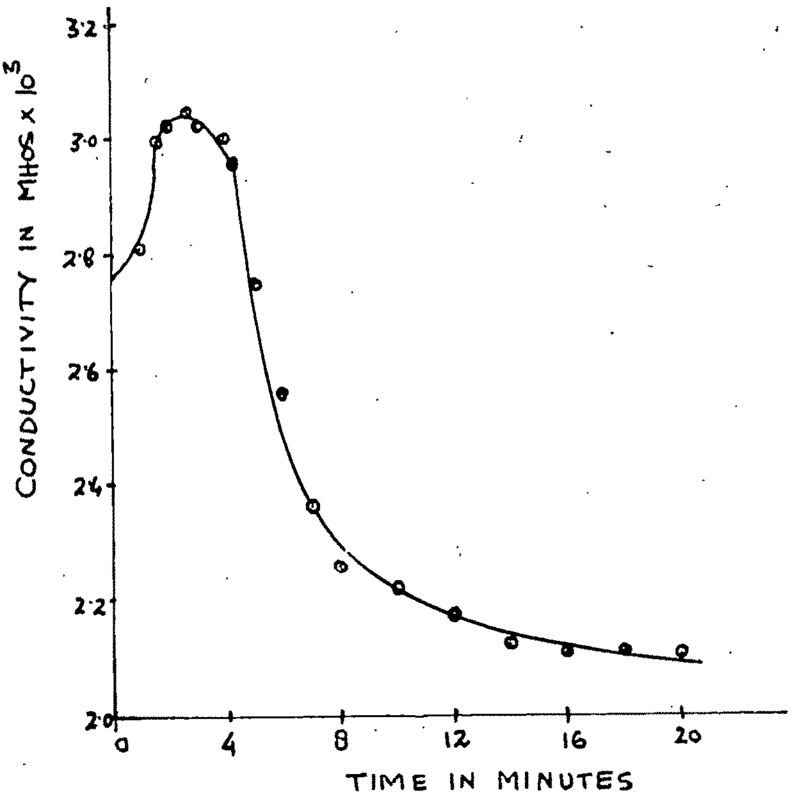


Fig. 2

Variations in Conductivity.



STUDIES ON GELS OF SODIUM OLEATE AND SODIUM ERUCATE IN A FRACTION OF TURPENTINE

PART II—EFFECTS OF SURFACE AREA AND LENGTH OF THE GEL COLUMN AND OF THE PRESENCE OF ADDITION AGENTS ON THE TIME AND TEMPERATURE OF SETTING OF THE GELS.

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In the previous paper (Part I) the author has given the results of his measurements of the time of setting of gels of sodium oleate and sodium erucate, prepared in a fraction of turpentine, and the effects of concentrations of these soaps and temperature on it. The present investigation deals with the study of the effects of surface area and length of the gel column and the presence of addition agents on the time and temperature of setting of these gels. The time of setting has been measured according to the definition given by Prasad by Fleming's method.

EXPERIMENTAL

1. *Materials Used*

The same fraction of turpentine and the same sodium oleate and sodium erucate as described in Part I were used. The additives used were sodium and potassium palmitates and stearates; the former were prepared from palmitic acid of B.D.H. quality and the latter from stearic acid of E. Merck quality, by standard methods.

2. *Effects of the length and surface of gels on the time of setting of sodium oleate and sodium erucate gel-forming solutions*

This was determined by using 4 per cent solutions of sodium oleate and sodium erucate, prepared at 140°C in pyrex glass test tubes of internal diameters (D) of 1·00, 1·25, 1·55 and 2·10 cms., in such a manner that the solutions in the test tubes stood at the height of 2·7, 4·5, 6·3 and 9·0 cm. The time of setting (t_s) in minutes obtained on cooling the gel-forming solutions of sodium oleate at 40°C and sodium erucate at 50°C are given in the Figs. 1 and 2, and 3 and 4, respectively.

3. *Effects of the presence of addition agents on the time of setting of sodium oleate and sodium erucate gel-forming solutions.*

This was determined by preparing gel-forming solutions containing 0·30 g. and 0·20 g. of sodium oleate and sodium erucate, respectively, in 10 ml. of the fraction of turpentine, at 140°C in pyrex glass test tubes of 1·55 cm. diameter and adding to them different amounts of sodium stearate, sodium palmitate and potassium stearate, and allowing the solutions to cool at 40°C. The results obtained are given in table 1 and 2 in which t_s represents the time of setting without the additives and Q the amount of additives.

4. *Temperatures of setting of sodium oleate and sodium erucate gel-forming solutions*

This was determined by allowing the gel-forming solutions of different concentrations (c) prepared at 140°C to cool at 50°C. The results obtained are shown in Fig. 5.

DISCUSSION OF RESULTS

1. *Effect of the length of the gel column*

The plots of the time of setting of gels against the heights (h) of the solutions in test-tubes of several diameters, shown in Figs. 1 and 3 bring out that (1) the time of setting of sodium oleate and sodium erucate gel-forming solutions of the same concentration prepared in test-tubes of the same diameter and cooled under the same conditions increases as the column of the solution setting to gel is increased and (2) the plotted points lie on straight lines, which are very nearly parallel in the case of sodium oleate gel-forming solutions. This shows that the time of setting of a gel is a linear function of the volume of the gel-forming solution. The increase in volume may affect the process of gelation in two ways : (1) it may delay the cooling of larger volumes of gel-forming solutions to the gelation temperature and hence to set to the gel state and (2) it may bring about alterations in the several stages involved in the gelation process because of the increase in the gel-forming units; the latter viewpoint seems valid because deviations from simple rules are observed in several physical properties of systems when their complexity increases.

2. *Effect of the surface of gels*

The plots of the time of setting of these gels against the diameters (D) of the test-tubes, shown in Figs. 2 and 4, bring out that (1) the time of setting of sodium oleate and sodium erucate gel-forming solutions of the same concentration prepared in test-tubes of different internal diameters filled to the same heights increases with the increase in the diameters of the test-tubes, and (2) the plotted points lie on straight lines.

According to the laws of cooling, the rate of cooling increases as the surface of the cooling system is increased. If this consideration is applied to the cooling of the gel-forming solutions, then they would be expected to cool down at a faster rate when the cooling surface is increased, that is, they would attain the gelation temperature or would set to get much earlier on increasing their surface. The observed results to the contrary show that the gel-forming solutions employed in this investigation do not behave like pure liquids or molecular solutions. Because the volumes of the gel-forming solutions increase when the diameters of the test-tubes are increasesd and the heights of the solutions are kept constant, the observed results can be explained on the same considerations as those advanced to explain the effect of increasing the lengths of the gel columns, discussed under (1). Further, since the increase in volume on increasing the diameter of the solution is much more than on increasing the height in the same proportion, the increase in the time of setting of gel-forming solutions prepared in test-tubes of increasing diameters will be much more than that observed on proportional increase of the length of the gel columns; this has actually been found. In the case of sodium oleate gel-forming solutions the increase in the time of setting on increasing the length of the column from 2·7-9·0 cm. for the four test-tubes used in this investigation ranges from half to one minute while for the increase in the diameter of the test-tubes from 1·00 to 2·10 cm. for various lengths, the increase in the time of setting ranges between 3·5-4·0 minutes. Similar observations have been made in the case of sodium erucate gel-forming solutions.

3. *Effect of the addition agents*

Tables 1 and 2 show that the effects of the addition agents is specific, with both gels of sodium oleate and sodium erucate. Using the same quantities of the addition agents, the time of setting decreases in the order:_
sodium stearate>sodium palmitate>potassium stearate.

4. *Temperature of Setting*

It was found by separate sets of experiments that for a gel-forming solution of a particular concentration the gelation temperature (T) is the same when it is cooled at different temperatures, that is, is independent of the temperature of the thermostat at which it is allowed to cool. This observation is in conformity with the findings of Deshpande and Buch[1] and reveals its significance as a specific property of gels. Hence in all experiments whose data are given in Fig. 5, the cooling of solutions of different concentrations was conducted at one temperature only, namely, 50°C.

It will be seen from the Fig. 5 that the gelation temperature increases for gels of both sodium oleate and sodium erucate as the amounts of these soaps in the gel-forming solutions are increased. The graphs in Fig. 5 further show that with a continuous increase in the amount of the soaps, the gelation temperature (T_g) increases at first very rapidly but subsequently the increase becomes fairly slow; the rate of increase in T_g in sodium erucate gels in the subsequent stage is comparatively slower than in gels of sodium oleate.

SUMMARY

The time of setting of gel-forming solutions of sodium oleate and sodium erucate of the same concentration prepared in test-tubes and cooled under the same conditions has been found to increase (1) with the increase of column of the solution setting to gel and (2) with the increase in the diameters of the test tube, and to decrease in the presence of additives in the order sodium stearate >sodium palmitate>potassium stearate. The gelation temperature (T_g) is unaffected by the temperature at which the solutions are cooled, but it increases with an increase in the amount of these soaps in the gel-forming solutions.

ACKNOWLEDGEMENTS

The author feels very grateful to Dr. Mata Prasad, D. SC., F.R.I.C., F.N.I., Emeritus Professor of Chemistry, St. John's College, Agra, for his guidance and suggestions throughout this work. He is also thankful to Dr. P. I. Ittyerah, Ph.D. (Agra), Ph.D. (Cant.), F.R.I.C., Head of the Chemistry Department, St. John's College, Agra, for providing him facilities for conducting this work. The author also feels grateful to the Director General C.S.I.R. for appointing him as the Research Assistant in the Retired Scientist Scheme working under Dr. Mata Prasad.

REFERENCE

1. Deshpande, K. B. & Buch, K. P. 1956. *J. Indian Chem. Soc.*, **33**: 321.

TABLE 1

Sodium oleate in 10 ml. of turpentine=0·300 g. t_B=1′51″

Q	Sodium Stearate	Sodium Palmitate	Potassium Stearate
0.0080	1′48″	...	1′35″
0.0093	...	1′42″	...
0.0236	1′45″	1′38″	1′26″
0.0500	1′40″	1′25″	...
0.0514	...	...	1′21″

TABLE 2

Sodium erucate in 10 ml. of turpentine=0·200 g. t_B=4′15″

Q	Sodium Stearate	Sodium Palmitate	Potassium Stearate
0.0026	...	4′00″	3′56″
0.0050	4′10″	3′56″	3′52″
0.0103	3′56″	3′46″	3′40″
0.0250	3′53″	3′30″	3′15″
0.0400	3′49″	3′26″	3′12″
0.0500	3′45″	...	...
0.1030	3′15″	3′00″	...

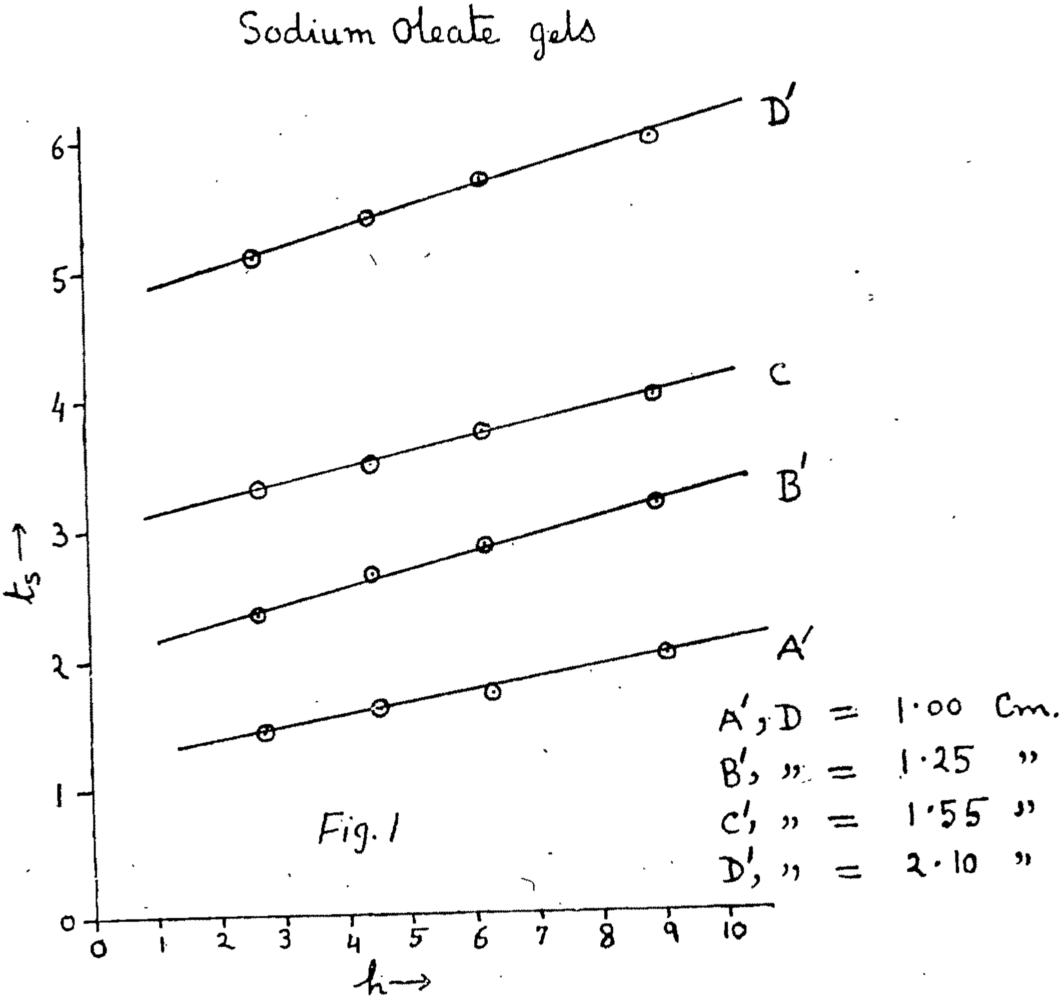

Sodium Oleate gels
D′
C
B′
A′
t_s →
h →
0
1
2
3
4
5
6
7
8
9
10
A′, D = 1·00 Cm.
B′, " = 1·25 "
C′, " = 1·55 "
D′, " = 2·10 "

Fig. 1

Sodium Oleate gels

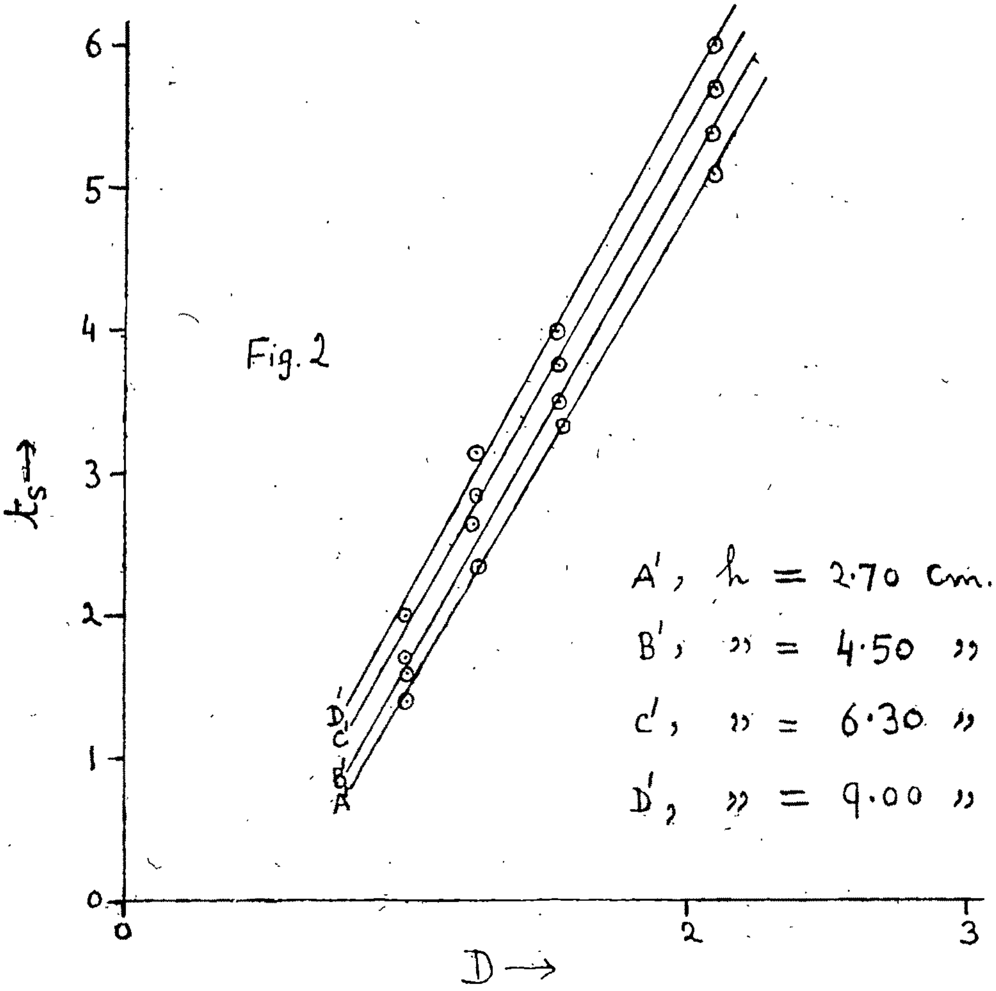


Fig. 2

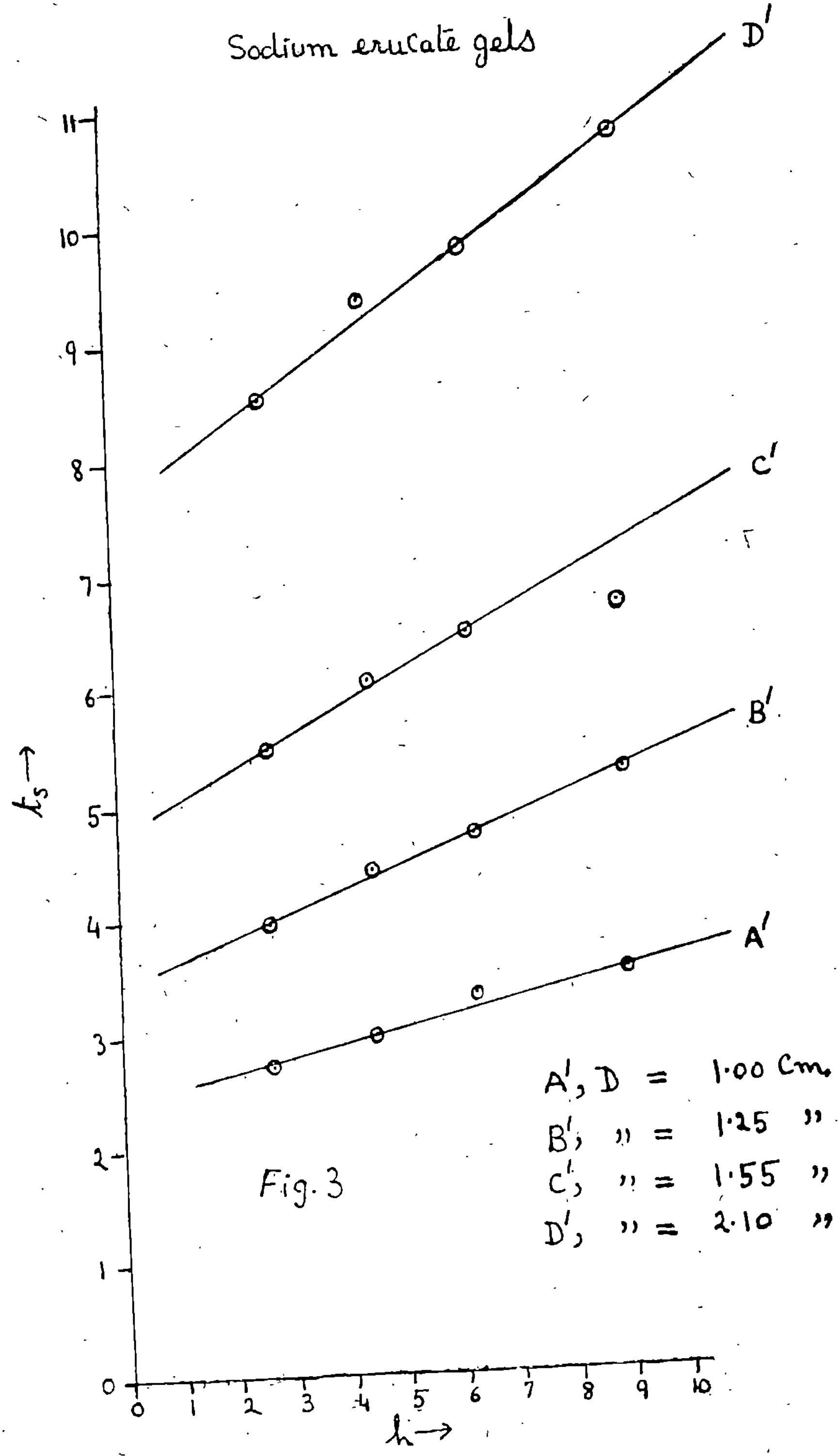
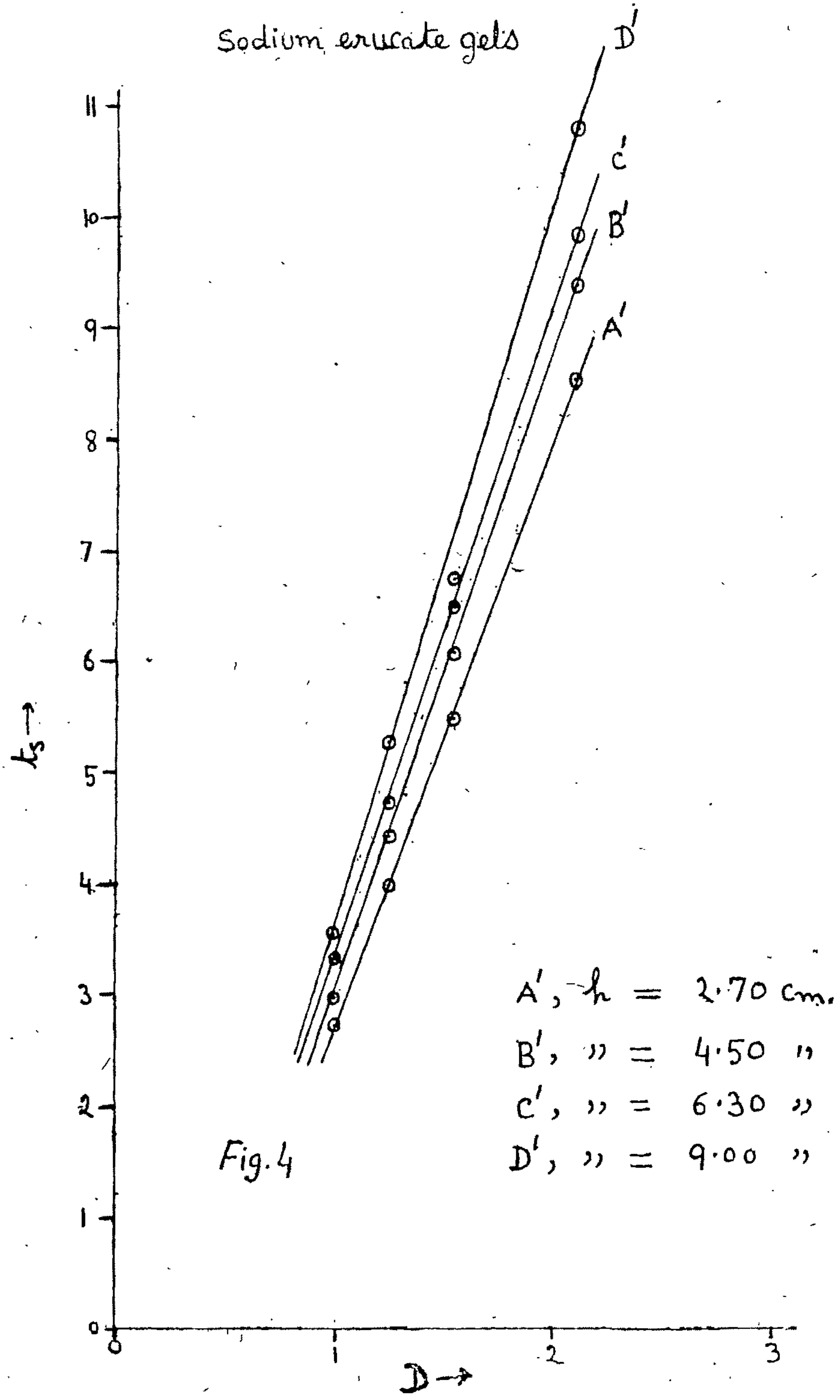

Sodium erucate gels
D'
C'
B'
A'
$t_s \rightarrow$
$h \rightarrow$
0
1
2
3
4
5
6
7
8
9
10
11
A', D = 1·00 Cm.
B', ,, = 1·25 ,,
C', ,, = 1·55 ,,
D', ,, = 2·10 ,,

Fig. 3



Sodium erucate gels

Fig. 4

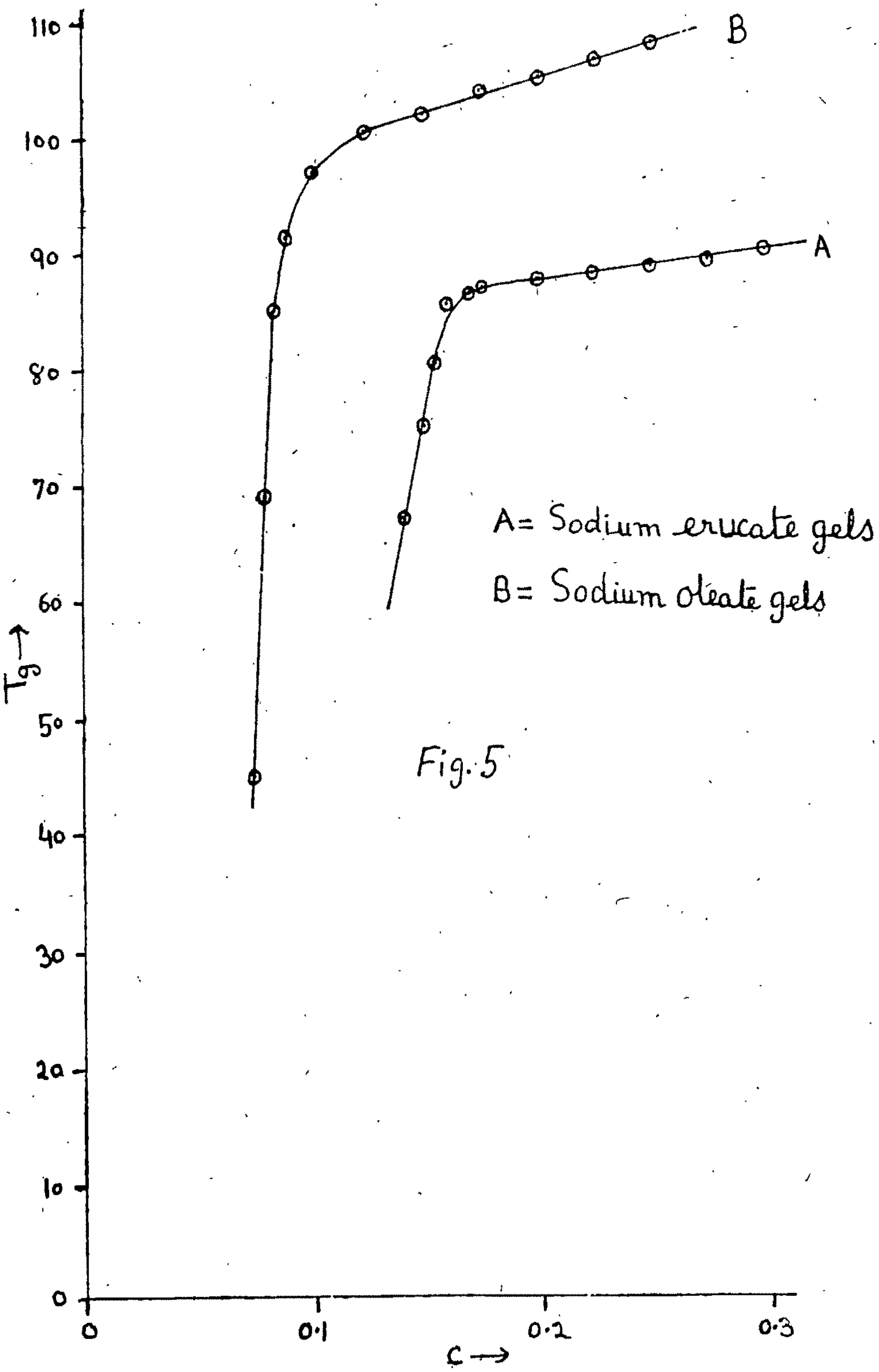

110
100
90
80
70
60
50
40
30
20
10
0
Tg →
0
0·1
0·2
0·3
C →
B
A
A= Sodium erucate gels
B= Sodium oleate gels

Fig. 5

STUDIES ON THE CRANIAL NERVES OF CLARIAS BATRACHUS (LIN.)

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INTRODUCTION

Clarias batrachus (Ord. Physostomi; Fam. Siluridae) is commonly available in ponds and streams of Muzaffarnagar. The fish possesses recemose type of accessory respiratory organs in the head region, as such their presence can effect the general distribution of the cranial nerves. With this assumption the present study was undertaken. For cranial nerves of fishes, references can be made to Wright (1885), Cole (1898), Juge (1899), Cole and Johnstone (1901), Atoda (1936), Bal (1937), Karandikar and Thakur (1954) and Sinha (1964).

Specimens of *Clarias batrachus* were procured from the local fish market and then preserved in four per cent formaline for some days which hardens the tissue and makes the dissection easier. After removing all the cranial roofings, the cranial nerves were dissected and studied under a stereoscopic microscope.

OBSERVATIONS

There are ten pairs of cranial nerves which emerge from the brain and innervate the sense and visceral organs. They are symmetrically displayed on either sides of the head.

The olfactory nerves (ol.n.) originate from the tips of the olfactory lobes which lie on the inner sides of the cerebral hemispheres. Each nerve is quite long and extends anteriorly upto the olfactory capsule where it dilates to form a somewhat oval but elongated olfactory bulb (ol. b.). The olfactory bulb gives out a prominent process to the olfactory sac, which along with the other minor processes from the olfactory bulb supply the olfactory sac. The olfactory nerves are of uniform thickness throughout.

The optic nerves (op.n.) arise from the anteromesial ends of the optic thalami of the diencephalon and run forward but obliquely below the cerebral hemispheres. They cross each other and partially fuse at the base on the ventral side of the diencephalon to form the optic chiasma. Each nerve then leaves the cranial cavity through the optic foramen in the cranium. Finally after running through the anterior and superior recti muscles, each nerve enters the eye ball of its own side to innervate the retina of the eye.

The oculomotor nerves (3) arise from the midventral surfaces of the mesencephalon just behind the saccus vasculosus. Each nerve is thin and on reaching the mid-ventral surface of the optic lobes, meets the trigeminofacial complex of its own side. The two together leave the cranial cavity through a large foramen. Finally the oculomotor nerve reaches the orbit and divides into two branches to supply the inferior oblique, anterior rectus, superior rectus and the inferior rectus muscles of the eye ball.

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The trochlear nerves (4) arise from the lateral surfaces of the mid brain between the optic lobes and the cerebellum. Each nerve leaves the cranium together with the trigeminofacial complex. Later, it proceeds forwards and downwards to supply the superior oblique muscles of the eye ball.

The abducens nerves (6) arise from the ventral surface of the medulla oblongata behind the facial lobes. Together with the trigeminofacial complex, each abducens leaves the cranium and runs downwards to innervate the posterior rectus muscles of the eye ball.

The trigeminal and facial nerves originate by a common trunk from the antero-lateral surfaces of the medulla just beneath the curve of the dorsal acoustic tubercles. Then, they separate but, remain quite close to each other to form a trigemino-facial complex. The trigemino-facial complex of each side leaves the cranium through a common foramen.

The trigeminal nerve runs dorsolaterally forwards into the orbit and gives out three branches, namely superficial ophthalmicus, maxillaris and mandibularis. Before giving off these branches, the trigeminal nerve dilates to form a sort of ganglion. In addition to these three branches there is also present a fourth band-like branch in this fish called the lateralis trigemini. Superficialis ophthalmicus (s.o.n.V.) extends forward anteriorly in association with the ophthalmicus branch of the seventh nerve. It bifurcates into two behind the eyes. These two branches (outer and inner) run above and below the olfactory sac to innervate the snout. The inner branch gives a branch which runs anteriorly downward to innervate the olfactory barbel. Maxillaris branch (max. n. V) runs anteriorly close to the buccalis branch of the facial nerve. It gives branches to the skin of the snout. It also gives branches to the maxillary barbel. The mandibularis branch (md. n. V) is comparatively thicker. It runs antero-laterally to enter the lower jaw and gives branches to the skin of the lower lip and finally divides to innervate the anterior and posterior mandibular barbels. Lateralis trigemini (lt. trg. n.) arises from the base of the trigeminal and runs upward making an angle of 120 degree with the latter. It runs dorsolaterally and extends upto the caudal fin of the fish where it divides into several branches. During its course it gives out small branches to the adjacent muscles.

The facial nerve also dilates at the base to form a ganglion-like structure. It also gives out three main branches, namely ophthalmico-superficial, hyomandibularis and buccalis. Ophthalmico-superficial (o.s.n. VII) runs in association with the superficial ophthalmicus branch of the trigeminal nerve and innervates the supera orbital canal of lateral line system. The hyomandibularis (hmd. n.

VII) is a stout nerve which runs anteriorly downwards. It gives off a thin branch, the palatinus facialis (p.f.n. VII) whioh runs anteriorly to supply the roof of the buccal cavity. Ventral to the origin of palatinus facialis, is given off another thin branch, the opercular (opt. VII) which innervates the opercular area.. The hyomandibularis, after giving these two branches goes downward and then divides into two unequal branches, the hyoideus (hd. n. VII) supplying the hyoidean muscles and the external mandibularis (mn.n. VII) supplying the mandibular area of the head.

The auditory nerves (au. n.) arise as thick nerves from the antero-lateral margins of the medulla oblongata between the trigeminofacial complex and the glossopharyngeal just beneath the dorsal acoustic tubercle. Soon, it divides into two branches, the vastibular and saccular. The vastibular branch runs outwards and divides fan wise to innervate the utriculus and ampullae of semicircular canals. The saccular branch runs backwards and its branches spread fan wise over the sacculus and lagena.

The glossopharyngeal nerves (gp. n.) arise from the lateral sides of the medulla, posterior to the dorsal acoustic tubercle. Each nerve perforates the posterior part of the auditory region and runs antero-laterally. On reaching the level of the first gillcleft it bifurcates to supply the first holobranch. A small branch comes out from the nerve before bifurcation and runs forward in association with palatine branch of facial nerve.

The vagus nerves (vg. n.) arise from the sides of the medulla just behind the origin of the ninth cranial nerves. For a very short distance each vagus nerve runs posteriorly along the side of medulla and then leaves the cranium through the vagus foramen. After leaving the cranium, it gives out four branchial nerves. All the branchials arise from one point. Each branchialis nerve divides into two branches, an anterior and a posterior one. The anterior branch called the pretrematic branch (pr.t.) runs forward along the anterior boarder of the cleft whereas the posterior branch, the posttrematic (ps.t.) branch runs deeper into the succeeding gill along the posterior boarder of the same cleft. The first branchialis (br. b. I) thus supplies the first and second gills; similarly the second branchialis (br. n. 2) to the third and fourth gills. The fourth branchialis (br. n. 4) supplies only the fourth gill. The accessary respiratory organs are innervated by the branches of these branchialis nerves. The posttrematic of the first branchial nerve and pretrematic of the second branchial nerve give branches to the accessory respiratory organs attached to the second gill arch. The pretrematic of third and fourth branchial nerves give branches to the accessory respiratory organs attached to the fourth gill arch. The visceralis branch (ve.n.) arises from the vagus just behind the branchial nerves and soon divides into two. The anterior branch runs forward on the floor of branchial cavity to innervate the pericardium and heart. The posterior branch runs backward and downward to supply the various organs of the body cavity. The lateralis branch (lt. n.) runs backward below the lateral line canal upto the caudal fin. Anteriorly after its emergence, it gives off dorsally a branch which runs over the occipital part of the head, to meet the fellow of the opposite side. Throughout its course the lateralis innervates the lateral line sense organs also.

DISCUSSION

Though the distribution of the cranial nerves in *Clarias batrachus* follow the general teleostean plan, yet there are certain features worth discussing.

1. In *Clarias*, the olfactory bulbs are of medium size and lie below the olfactory sac which it innervates by its branches. Similar condition has also been reported in *Mystus cavasius*, *Heteropneustes fossilis* (Mookerjee et. al, 1950) and *Wallago attu* (Sinha, 1964). The former authors further suggested that the olfactory bulbs are of medium size in those fishes that feed by sight and taste.

2. The optic nerves of *Clarias* not only cross each other ventrally but also fuse partially at the base. Such condition of optic nerves has also been reported in *Catla catla*, *Cirrhina reba*, and *Barbus chola* (Mookerjee et.al., 1950). In *Wallago attu* (Sinha, 1964) the two nerves only cross each other and are separable.

3. The fifth and seventh cranial nerves of most of the teleost fishes, emerge out through several distinct roots. The number of these roots differ in different species. Juge (1899) found a single trunk common to both nerves on each side of *Silurus;* Cole and Johnstone (1901) described three roots in *Pleuronectes*, one of the trigeminal and two of the facial nerve; Bal (1937) reported four roots in *Tetrodon*, two of the trigeminal and two of the facial nerve. In *Clarias batrachus*, the two arise separately; the two are, however, quite close to each other to form the trigeminofacial complex. Sinha (1964) has also reported the separate origin of fifth and seventh nerves in *Wallago attu* which soon join to form the trigeminofacial complex. The presence of trigeminofacial complex has also been reported by Atoda (1936) in *Parasilurus asotus* and by Karandikar and Thakur (1954) in *Sciaenoides brunneus*. The ophthalmicus profundus is absent in the present fish but has been reported as presnt in *Scombr scomber* (Allis, 1903). Lateralis trigemini of trigeminal nerve, similar to that of *Mystus seenghala* (Uberoi, 1959) has also been observed in *Clarias*.

4. Sinha (1964) has reported the independent origin of lateralis branch from the brain in *Wallago attu* but in *Clarias* the lateralis represents a branch of the vagus nerve like that of *Wallago attu* (Sinha, 1964). The branchialis are four in *Clarias*. These branchialis also innervate the accessary respiratory organs found attached to second and fourth gill arches.

SUMMARY

1. The olfactory nerve extends upto the base of olfactory sac. The olfactory bulbs are of medium size. The optic nerves cross and partially fuse at the base.

2. The oculomotor nerve innervates the inferior oblique, anterior, superior and inferior recti muscles. The trochlear nerve supplies only the superior oblique muscle while the abducens innervates the posterior rectus muscle of the eye ball.

3. The fifth and seventh cranial nerves form a trigeminofacial complex. The trigeminal gives off superficial ophthalmicus, maxillaris and mandibularis branches as well as a lateralis trigemini branch. The ophthalmicus profundus is absent. The facial nerve gives off ophthalmico-superficial, hyomandibular and buccalis branches.

4. The barbels are supplied by the branches of trigeminal nerve. The olfactory barbels are innervated by the branches of the superior ophthalmicus and the maxillary barbels by the branches of the maxillaris nerve, the mandibular barbels get their nerve supply from the branches of the mandibularis nerve.

5. The auditory nerve has vestibular and saccular branches. The former supplies the utriculus and ampullae of semicircular canals whereas the saccular branch innervates the sacculus and lagena.

6. The glossopharyngeal nerve divides into two and innervates the first gill. There are four branchialis branches of the vagus nerve and all are divided into pre- and post-terematic branches which supply the holobranches. The visceralis branch of the vagus divides into anterior and posterior branches; the anterior branch innervates the heart and pericardium and the posterior branch the viscera. The lateralis supplies the lateral line canal. It also gives off a dorsal branch from its base which meets the fellow of the opposite side dorsally to form a commissure.

7. The accessory respiratory organs are innervated by the branches given out from the branchialis. The organ of the second gill arch is supplied with branches which arise from the post trematic of the first branchialis and the pretrematic of the second branchialis. The organ of fourth gill arch is supplied with branches which arise from the pretrematic of the third and fourth branchialis.

REFERENCES

1. Allis, E. P. 1903. The Skull and the cranial and first spinal muscles and nerves in *Scomber scomber. Jour. Morph.* **18** (2): 45-328.
2. Atoda, K. 1936. The innervation of the cranial nerves of catfish, *Parasilurus asotus. Sci. Rep. Tohoku. Univ.* **11**: 91-115.
3. Bal, D. W. 1937. Studies on Indian puffers or globe fishes. III. The nervous system of *Tetredon oblongus. J. Univ.* Bombay, **5** (5): 44-57.
4. Cole, F. J. 1898. Observations on the structure and the morphology of the cranial nerves and lateral line sense organs of fishes. *Trans. Linn. Soc.* London, **7.**
5. Cole, F. J. & Johnstone, J. 1901. Pleuronectes. L.M.B C. series.
6. Juge, M. 1899. Recherches sur lies nerbs cerebraux et. al. musculative cephaliqule de *Silurus glanis. de la Revue. Suisse de Zoologie. T.* **6.**
7. Karandikar, K.R. & Thakur, S.S. 1954. *Sciaenoides brunneus* Day. Anatomy with notes on distribution and Bionomics. - The *Univ. Bombay Zoological memoirs.* **3**: 71-80.
8. Mookerjee, H.K., Ganguly, D.N. & Mookerji, P.S. 1950. Study on the structure of the brains of some Indian fishes in relation to their feeding habits. *Proc. Zool. Soc.* Bengal. **5**: 119-145.
9. Sinha, B.M. 1964. The cranial nerves of *Wallago attu. Proc. Nat. Acad. Sci. India,* **34** (B): 42-48.
10. Uberoi, I.B.S. 1959. Nervous system of *Mystus seenghala.* M. Sc. Thesis, Punjab University (Unpublished).
11. Wright, E.E. 1885. On the nervous system and sense organs of *Ameiurus catus. Proc. Cand Inst. Sci.,* **2**: 352-381.

PLATE I

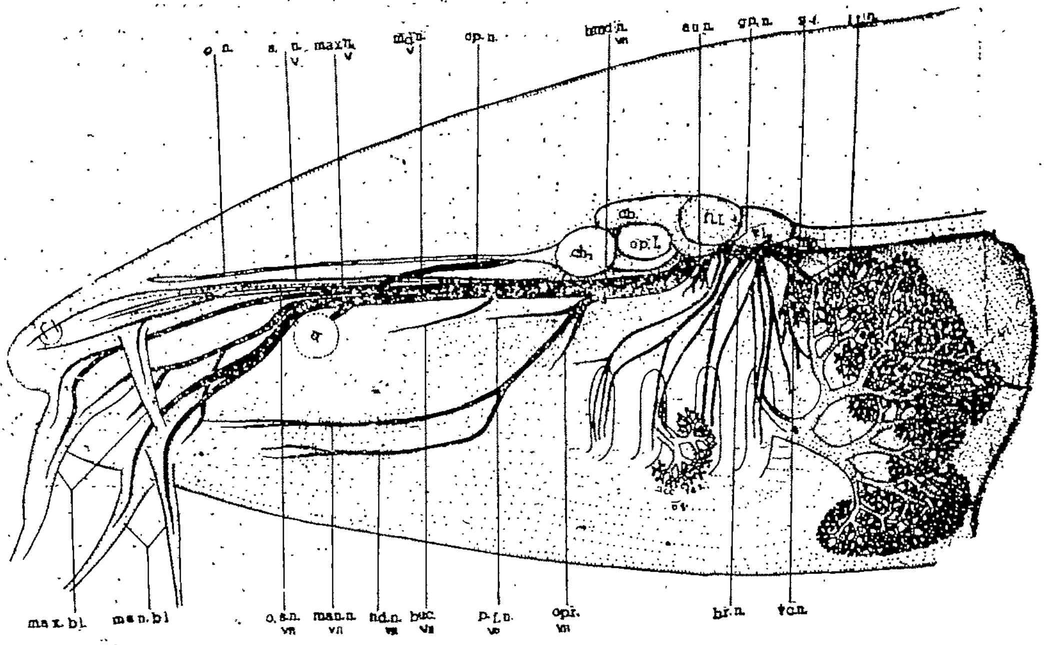

Fig. 1

Fig. 1. Lateral view of the head of *Clarias batrachus* showing cranial nerves.

acc. res. og., accessory respiratory organs; au. n., auditory nerve; br. n., branchialis nerve; buc., buccalis; c. b., cerebellum; c. h., cerebral hemisphere; e., eye; f. l., facial lobe; gp. n., glossopharyngeal nerve; hd. n. VII, hyoideus nerves; hmd. n., hyomandibular nerve; lt. n., lateralis nerve; m. o., medulla oblongata; max. n. V, maxillary nerve; max. bl., maxillary barbel; md. n. V, mandibularis nerve; man. n. VII, mandibular nerve; man. bl., mandibular barbel; ol. n., olfactory nerve; op. l., optic lobe; op. n., optic nerve; opr. VII, opercular; o.s.n. VII, ophthalmico-superficial facialis nerve; p. f. n. VII, palatinus facialis nerve; s o.n. V, superficial ophthalmicus nerve; v.l. vagal lobe; vg. n., vagus nerve; vc. n., visceralis nerve.

PLATE II

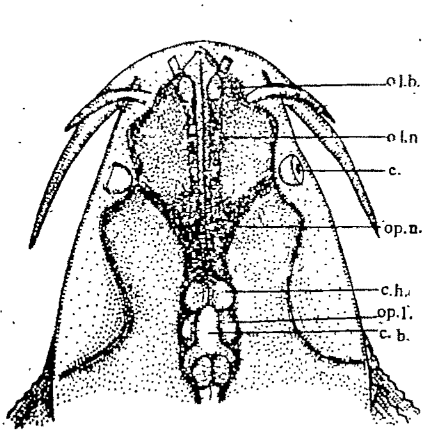

Fig. 2

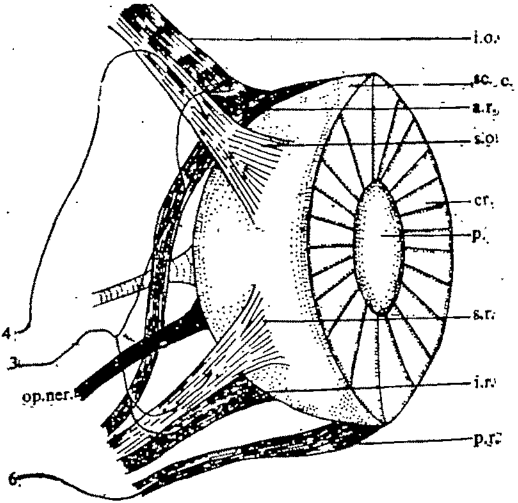

Fig. 3

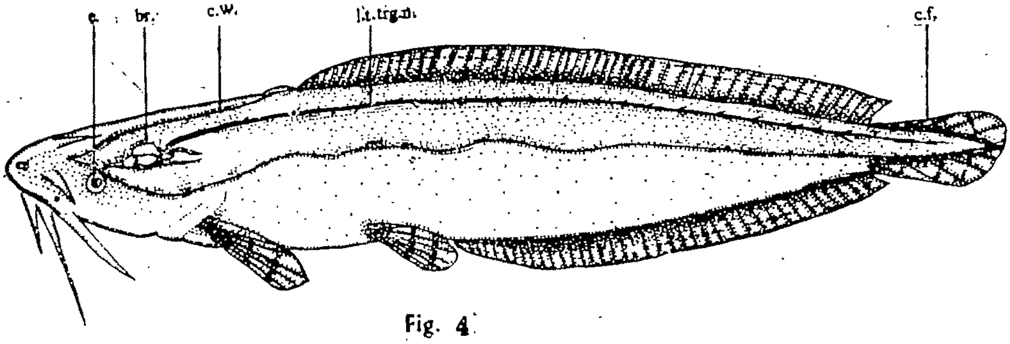

Fig. 4

Fig. 2. Dorsal view of the dissected head of *Clarias batrachus* showing olfactory and optic nerves X2.

Fig. 3. Nerve supply to the eye ball and eye muscles in *Clarias batrachus*.

Fig. 4. Dissection showing lateralis trigemini nerve in *Clorias batrachus*. X2

a.r., anterior rectus; br., brain; c.b., cerebellum; c. f., caudal fin; c.h., cerebral hemisphere; cr., cornea; c. w., cut wall; e., eye; i.o., inferior oblique muscle; i.r., inferior rectus muscle; lt. trg. n., lateralis trigemini nerve; ol. b., olfactory bulb; ol. n., olfactory nerve; op. l., optic lobe; op. n., optic nerve; p., pupil; p. r., posterior rectus muscles; sc. c., sclerotic coat; s. o., superior oblique muscle; s. r., superior rectus muscle; 3., oculomotor nerve; 4., trochlear nerve; 6., adducens nerve.

PLATE III

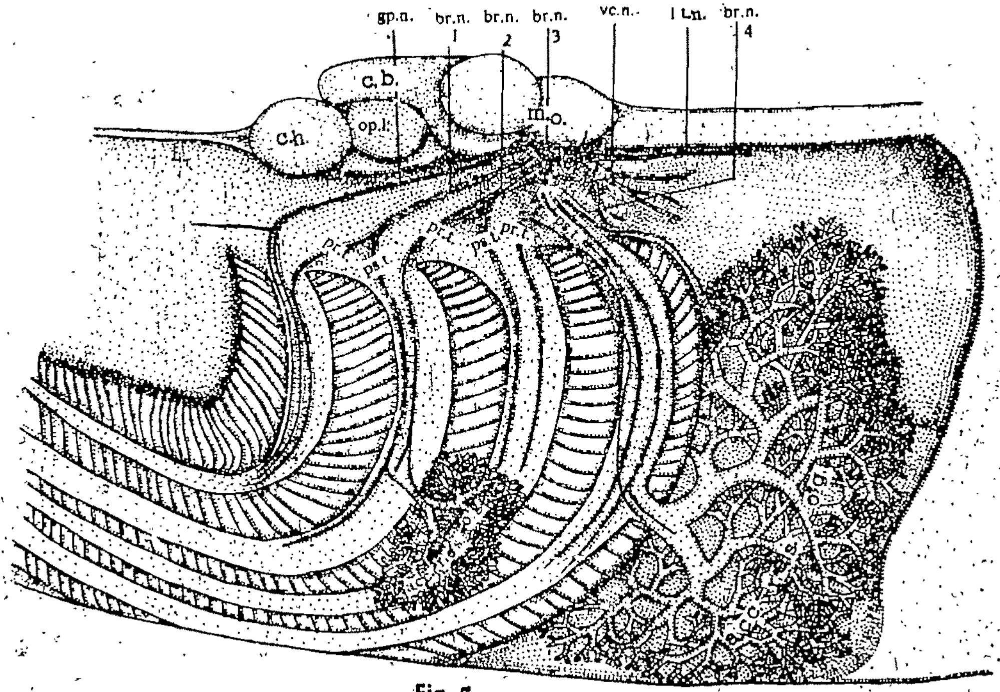

Fig. 5.

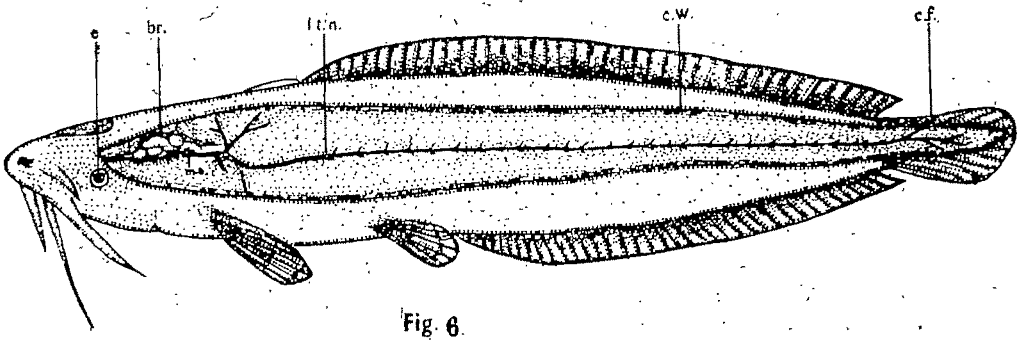

Fig. 6.

Fig. 5. Dissection showing glossopharyngeal and vagus nerve branches in *Clarias batrachus*.
Fig. 6. Dissection showing lateralis nerve in *Clarias batrachus*.

acc. res. og., accessory respiratory organ; br., brain; br. n. 1—4, branchial nerve 1—4; c. b; cerebellum; c. f., caudal fin; c. h., cerebral hemisphere; c. w., cut wall; e., eye; gp n., glossopharyngeal nerve; lt. n, lateralis nerve; m. o., medulla oblongata; op. l. optic lobe; pr. t., pretrematic; ps. t., posttrematic; vc. n, visceralis nerve.

PLASMA PROTEIN FRACTIONS AND SERUM CALCIUM CONTENT IN LAYING AND NONLAYING FOWLS

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Since during growth and egg laying the metabolic pattern in birds is dominated by changes in protein and calcium metabolism, the present study was undertaken to determine the variations in total protein, protein fractions and calcium content in serum of growing birds and of birds during laying and non-laying periods. The free amino acids present in the blood plasma during laying and non-laying periods were also studied.

Material and Methods

1. *Birds used in experiment*

The pertinent information regarding the age groups of the White Leghorn chicken, collection of materials and management of birds have been described in an earlier paper (Bist *et al.*, 1967).

2. *Methods used*

Total protein was estimated by micro-Kjeldahl method. Fractionation of serum proteins was carried out by paper electrophoresis using a Zeiss Jena paper electrophoresis apparatus using the following two buffers:—

(1) Barbiturate buffer (pH 8·6, ionic strength 0·05) and
(2) Veronal acetate buffer (pH 8·6, ionic strength 0·05)

Electrophoresis was allowed for 16 hours at 125 volt and current strength of one milliampere per strip. The electropherograms were stained using bromophenol blue according to Block *et al.*, (1958).

Calcium was estimated by the method of Clark and Collip as given in Hawk *et al.*, (1952).

Resolution of free amino acids in plasma was carried out by two dimensional paper chromatography using the solvents (1) Butanol: acetic acid: water (40 : 10 : 50 v/v) for the first run and phenol : water (75 : 25 w/v) for the second run. The amino acid spots were identified by spraying the paper sheet after chromatography with ninhydrin solution in butanol.

Results and Discussion

In table 1 to 3 are given the values of total protein content, concentration of different protein fractions and albumin/globulin ratios of serum of different categories of birds examined. Electrophoretic fractions of the serum proteins are shown in Figs. I to V. Data on calcium content of serum have been collected in table 4.

A gradual increase in concentration of total serum protein was observed (Table 3) with increase in age of the birds. Upto 7 days, chicks had an average protein value of 2·93 gm/100 ml. of serum and as they reached an age of 8 weeks, the value rose to 3·79 gm/100 ml. The intermediate values were 3·43 and 3·66 gm/100 ml. at 2 and 4 weeks. The values for 16 week old pullets, non-layers and cocks were 4·28, 4·69 and 4·02 gm/100 ml. respectively while those of the layers and moulters were 6·01 and 5·37 gm/100 ml. respectively.

Four protein components, corresponding to albumin, alpha (L_1+L_2), beta and gamma globulins were obtained as a result of electrophoretic fractionation of serum samples from various types of birds (Figs. I to IV). Albumin the fastest moving fraction had a concentration ranging from 56·9 to 75·6 per cent. The average concentration of this fraction in the serum of chicks was 51·3 per cent and that in case of laying and non laying hens was 45·1 per cent (Tables 1 and 2). It may be observed that the concentration of this fraction was highest in case of chicks and lowest in laying hens. The average value for albumin/globulin ratio was found to be 2·3 upto 7 days; 1·5 in 4-8 week old chicks; 1·05 in non-laying hens and 0·84 in laying hens. Thus as the birds increased in age, the ratio gradually declined. The absolute values of albumin and globulin fractions were, however, higher in mature birds than in case of chicks.

In only a few cases the two fractions of alpha globulin i.e. L_1 and L_2 could be obtained separately. The L fraction obtained was 8·6% in upto 7 day old chicks, 11·0% in 4-8 week old chicks and 12·3 and 9·1% in non laying and laying hens. The per cent concentration of β-globulin was observed to be highest (14·4%) in case of laying hens. In all other cases the value for this fraction was more or less the same and ranged from 10·2 to 10·8. The concentration of the gamma globulin fraction was low in upto 7 day old chicks (12·1%), but continued to increase with age. It was 19·5% at 4-8 weeks, 26·2% and 31·8% in non-laying and laying hens. One fraction moving ahead of albumin was observed in the serum samples of two laying hens Fig. 4 (2). The concentration of this fraction was only 6·3% of the total serum protein. Duetsch and Goodloe (1945), Brandt *et al* (1951), Shimizu and Itabashi (1954) and Tanaka and Aoki (1963) also observed the presence of such a fast moving fraction in the serum of some laying birds. The electrophoretic fractionation of the serum protein fractions was found to be brought about better by using barbiturate buffer of pH 8·6 and ionic strength 0·05 as compared to the veronal acetate buffer of pH 8·6 and ionic concentration 0·05.

Serum calcium concentration of various age groups are presented in table 4. It was slightly lower in upto 7 day (10·50 mg) and 15 day old (10·46 mg) chicks in comparison to 4 week (11·10 mg) and 8 week old (11·41 mg) chicks. The value in case of 16 week old pullets rose to 13·30 mg.; for non-layers and moulters the values were 12·87 and 12·07 mg. per 100 ml. of serum respectively.

The maximum value was obtained in the laying birds (22·33 mg.). Joshi *et al* (1963) had reported that in laying and non-laying W.L. birds the serum calcium content was 29·60 ± 10·7 and 15·66 ± 1·44 mg. respectively.

The average value of calcium in serum in case of cocks was found to be only 11·76 ± 0·384.

Free amino acids present in the blood serum of laying and non-laying birds were identified by using two-dimensional chromatography. Seventeen amino acids (viz. Cysteine, aspartic acid, glutamic acid, serine, lysine, glycine, histidine, alanine, tryptophane, tyrosine, arginine, proline, valine, methionine, phenyl, alanine, isoleucine and leucine) were found in both the laying and non-laying birds.

SUMMARY

1. Total serum protein content of chicks of various age groups, cocks pullets, laying, non-laying and moulting birds were estimated. The value increased with age and it was highest in case of laying birds.

2. Investigations on the relative concentration of protein fractions in the above birds revealed four components; namely, albumin, (alpha$_1$ and alpha$_2$), beta and gamma globulins in serum. Per cent concentration of albumin fraction was maximum in chicks and least in laying birds. Beta globulin fraction was more in case of laying birds. Gamma globulin fraction was least in upto 7 day old chicks (12·1%) but it gradually increased with age. The concentration was maximum in laying hens. A fast moving fraction was detected in the sera of only two laying birds, out of the 130 birds screened.

3. While serum calcium content in one day to 8 weeks remained more or less constant it was found to be significantly more in four month old pullets. The highest concentration was found in laying hens.

4. Free amino acids present in the plasma of laying and non-laying birds were identified using two dimensional paper chromatography. Seventeen amino acids were detected in the plasma of both the types of birds.

REFERENCES

1. Bist, S. S., Rawat, J. S. & Roy, A. 1967. (Under publication)
2. Block, R. J., Durrum, E. L. & Zweig, G. 1958. A Manual of Paper Chromatography and Paper Electrophoresis, 2nd ed., Academic Press, N. Y. p. 576.
3. Brandt, L. W., Clegg, R. E. & Andrews, A. C. 1951. *J. Biol. Chem.*, 191, 105.
4. Duetsch, H. F. & Goodloe, M. B. 1945. *J. Biol. Chem.*, 161, 1.
5. Joshi, H. B., Rajdan, M. N. & Pal, A. K. 1963. *Ind. Vet. J.* **40**: 467.
6. Shimizu, H. & Itabashi, H. 1954. *J. Agric. Res.*, **8**: 1.
7 Tanaka, K & Aoki, S. 1963. *Nat. Inst. Anm. Hlth. Quart. Tokyo.* **5**; 49, cited in *Vet. Bull.*, **33**: 524.

TABLE 1

Total Protein, Percentage of Different Protein Fractions and Albumin/Globulin Ratio in the Serum of White Leghorn Chicks at Various Ages

Sl. No.	Age of the birds	Total protein gm./100 ml.	Albumin %	Globumin%			A/G Ratio
				Alpha	Beta	Gamma	
1.	Upto 7 days	2·93	69·6	8·6	10·7	12·1	2·3
	Range	(2·73—3·05)	(57·0—75·6)	(5·7—12·3)	(7·6—13·2)	(8·5—17·5)	(1·3—3·1)
2.	4—8 weeks	3·69	59·3	11·0	10·2	19·5	1·5
	Range	(3·47—3·95)	(55·1—64·6)	(8·9—12·4)	(9·0—11·4)	(16·5—22·1)	(1·2—1·8)

TABLE 2

Total Protein, Percentage of Different Protein Fractions and A/G Ratio in the Serum of White Leghorn Laying and Non-Laying Birds

Sl. No.	Type of birds	Total protein gm./100 ml. serum.	Albumin %	Globumin%			A/G Ratio
				Alpha	Beta	Gamma	
1.	Non-laying hens	4·56	51·3	12·3	10·8	26·2	1·05
	Range	(4·15—5·05)	(45·8—59·3)	(6·6—18·3)	(8·4—15·2)	(20·1—31·6)	(0·85—1·46)
2.	Laying hens	5·71	45·1	9·1	14·4	31·8	0·84
	Range	(5·28—6·50)	(36·7—52·6)	(3·6—19·0)	(9·4—18·6)	(21·5—39·1)	(0·58—1·11)

TABLE 3

Average Protein Values of Serum of White Leghorn Birds at Different Stages

Sl. No.	Stage of the birds	Total protein gms./100 ml.	Standard Error	Range
1.	Upto 7 days old	2·93	0·06	2·73—3·05
2.	15 days old	3·43	0·07	3·27—3·64
3.	4 weeks old	3·66	0·05	3·44—3·95
4.	8 weeks old	3·79	0·05	3·50—3·98
5.	16 weeks (Pullets)	4·28	0·10	4·05—4·52
6.	Cocks	4·02	0·05	4·10—4·34
7.	Non-layers	4·69	0·06	4·15—5·12
8.	Layers	6·01	0·21	5·04—7·26
9.	Moulters	5·37	0·07	4·75—6·16

TABLE 4

Average Calcium Content of Serum of White Leghorn Birds at Different Stages

Sl. No.	Stage of the birds	Calcium mg./100 ml.	Standard Error	Range
1.	Upto 7 days old	10·50	0·35	9·6—11·5
2.	15 days old	10·46	0·27	9·6—11·0
3.	4 weeks old	11·10	0·23	10·0—12·2
4.	8 weeks old	11·41	0· 3	10·6—12·6
5.	16 weeks (Pullets)	13·30	0·35	12·4—14·2
6.	Cocks	11·76	0·38	10·8—12·6
7.	Non-layers	12·87	0·04	10·6—15·2
8.	Layers	22·33	0·09	18·4—25·4
9.	Moulters	12·07	0·18	10·8—13·6

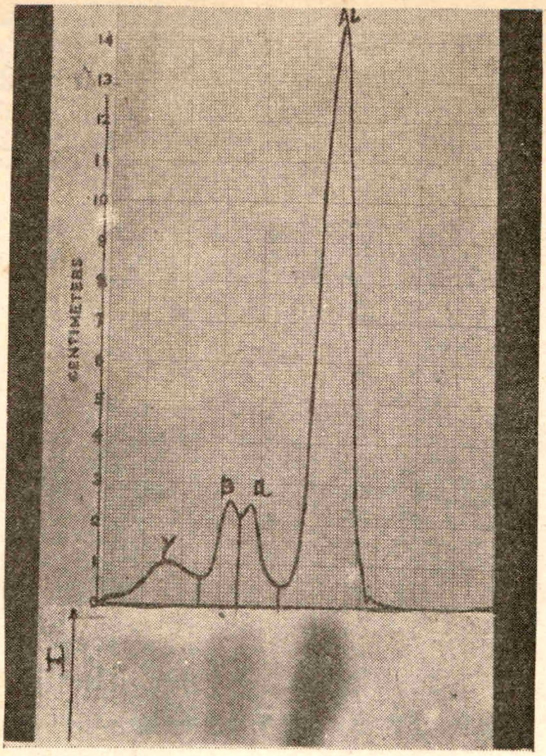

Fig. 1. Filter paper strip with graph showing the electrophoretic pattern of 0–7 days chick serum.

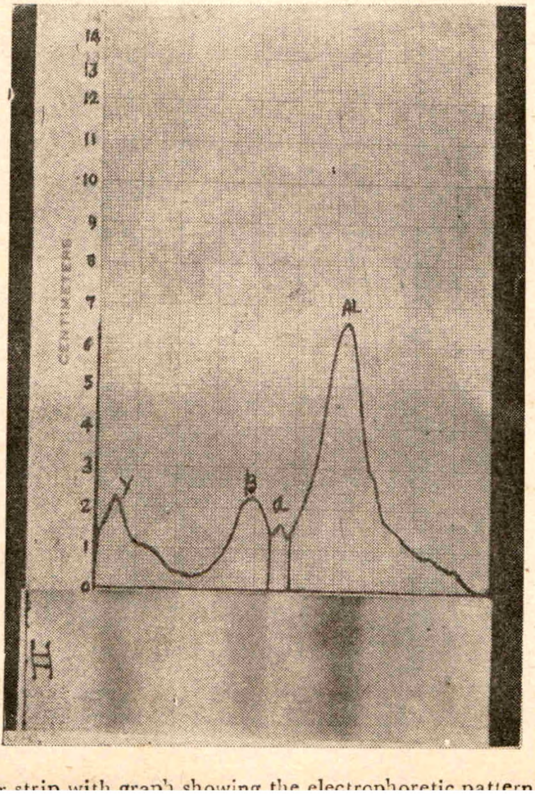

Fig. 2. Filter paper strip with graph showing the electrophoretic pattern of 4–8 weeks

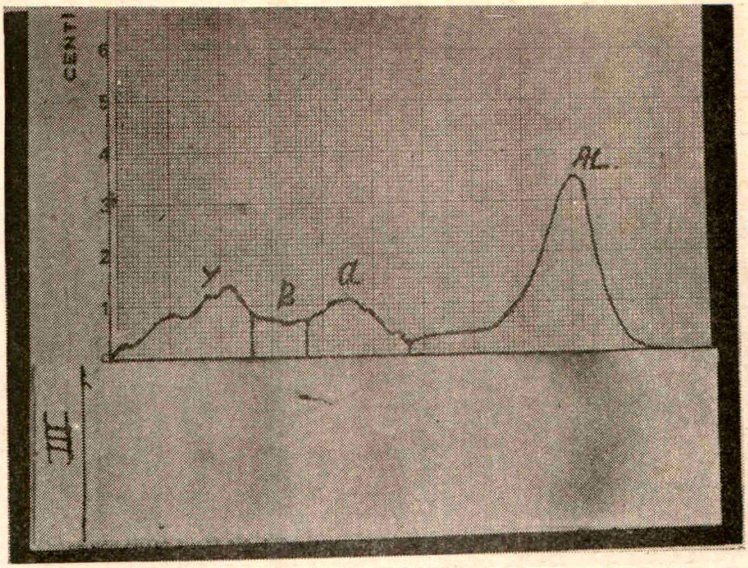

Fig. 3. Filter paper strip with graph showing the electrophoretic pattern of nonlaying birds serum.

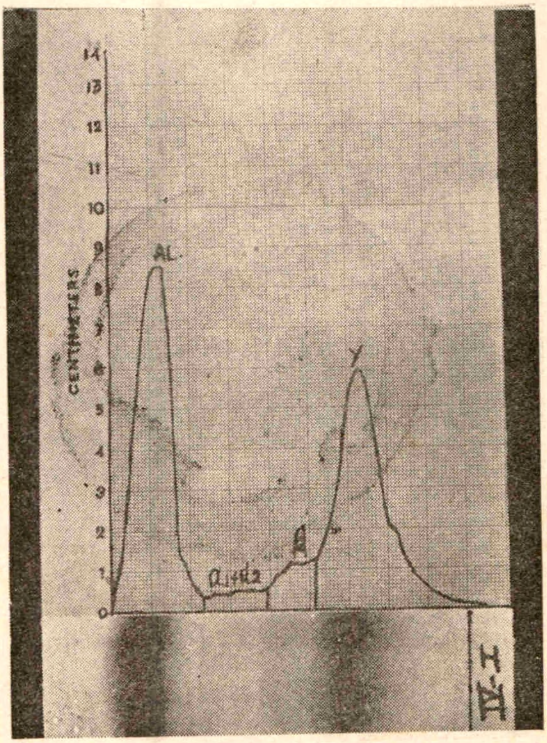

Fig. 4 (1). Filter paper strip with graph showing the electrophoretic pattern of laying birds serum.

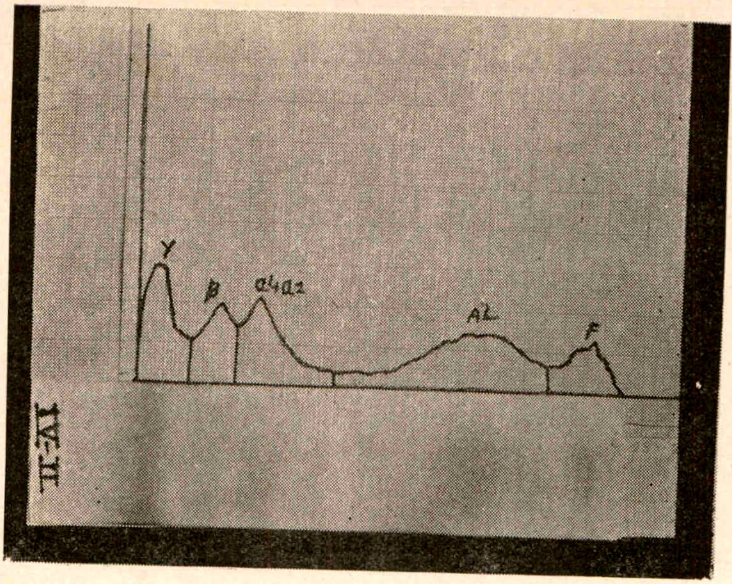

Fig. 4 (2) Filter paper strip with graph showing the electrophoretic pattern of laying birds serum with a fast moving component (F).

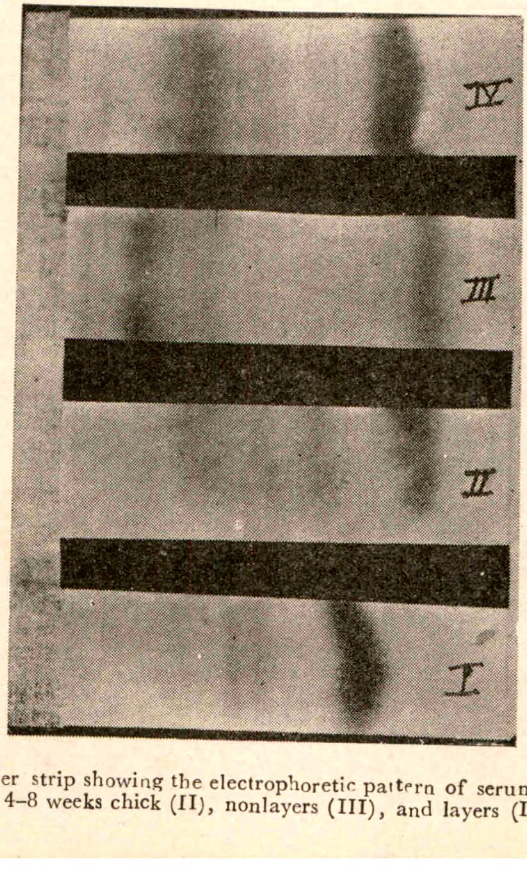

Fig. 5. Filter paper strip showing the electrophoretic pattern of serum of 0–7 days chick (I), 4–8 weeks chick (II), nonlayers (III), and layers (IV).

CYTOLOGICAL STUDIES ON CESTRUM CORYMBOSUM

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The genus *Cestrum* of Solanaceae is represented in tropical America by about 325 species most of which are shrubs and small trees. Many of these are now grown in warm countries of the globe for their attractive and often fragrant flowers (Anonymous, 1950). Some of these are medicinally important because they yield toxic alkaloids and chlorogenic acids.

A perusal of the literature (Darlington and Wylie, 1955) reveals that only fragmentary cytological work has been done on members of this genus. The chromosome number for *C. nocturnum* L. (Bhaduri, 1933); *C. parqui L. Her* (Schack and Covas, 1947); *C. purpureum* (Elegans) (Carnail, 1963) and *C. diurnum* (Mehrotra and Vig, 1963) has been reported to be 2n=16. Mehrotra and Vig, (1963) have reported a normal meiosis in *C. diurnum* despite a high degree of stickiness of chromosomes at metaphase I and in later stages. Detailed investigations on the same species carried out in this department, however, has revealed a high degree of meiotic abnormalities in the form of segmental and intersegmental interchanges (Dubey and Singh, 1964). These cytological abnormalities have been found to be the factors responsible for pollen sterility and poor seed set. Cytological investigations on *C. corymbosum* have been undertaken to find out chromosome number and to determine the cause for semisterility in the plant.

Material and Methods

Flower buds of the appropriate size were collected at 9 a. m. from Forest Research Institute, Dehra Dun in the month of October, 1964 and fixed in 1 : 3 acetic alcohol for 24 hours prior to storage in 70% ethyl alcohol. Ordinary acetocarmine squash technique gave satisfactory results. Permanent preparations were made in acetic acid-N. butyl alcohol series.

Observations and Discussion

Well spread somatic metaphase plates obtained from tapetal cells showed 16 chromosomes (Fig. 1). The same chromosome number has been reported for *C. nocturnum L.* (Bhaduri, 1939); *C. parqui L.* Her (Schack and Covas, 1947) *C. diurnum* (Mehrotra and Vig, 1963). Though chromosome number of other species of the genus are yet unknown, it seems quite likely that 8 is the base number for the entire genus. Deep staining of the cytoplasm obscured finer details of meiosis. However, the best analysable stages during meiosis were diplotene, diakinesis and metaphase I. All of which showed 8 bivalents in the majority of PMC (Fig. 2) except in a few cases where number of abnormalities, such as multivalents, chromatin bridges, laggards and supernumarary nucleoli were observed.

In some of the microspore mother cells multivalent formation were observed. The most common configuration was a chain of three chromosomes and a univalent besides 6 II at diplotene (Fig. 3). The chain configuration seems to be due to a small terminal interchange between non-homologous chromosomes; the univalent arising as a result of the complete terminalisation of chiasma and/or a complete failure of chiasma formation. Similar chains have earlier been reported in *Paeonia californica* (Walters, 1942,; Datura (Blakeslee, 1928) and many other angiosperms (see Burnham, 1962). At anaphase I one or two chromatin bridges and laggards were also observed in a few cells (Fig. 5 & 6) which are probably due to the formation of dicentric chromosomes and acentric fragments.

The sporogenous cells of *C. corymbosum* display a great variation in the number of nucleoli. Though majority of the sporogenous cells possess a single, well stained, spherical nucleolus (Fig. 2) but cells with more than one nucleolus were also present. A maximum of four nucleoli was observed in small percentage of cells (Fig. 4). The accessory nucleoli were of varying sizes and remained associated with different bivalents. The number of nucleoli per nucleus has been considered as a fairly reliable criterian to indicate the level of polyploidy in some plants (Bhaduri and Kar, (1948). Contrary views have been put forward by Hakansson and Levan (1942); Matsura 1938); Tandon and Kapoor (1961) and Koul (1964). In the present species the number of nucleoli is variable in the nuclei of different cells with the same chromosome number. This furnishes a strong support to the view that the nucleolar number can not be used as an index to determining ploidy.

In a small percentage of cells chromosomes exhibited a tendency to keep clumped together in a mass (Fig. 7). This type of stickiness was also reported in *C. diurnum* by Mehrotra and Vig (1963). Beadle (1932, 1937) has reported a gene for stickiness in *Zea mays*. The probable reason for stickiness in the genus *Cestrum* remains still unknown.

The second division is characterised by a number of irregularities. The various abnormalities met with at this stage are (i) the irregular separation of daughter chromosomes (Fig. 8); (ii) the occurrence of chromatin bridges (9 & 10) and (iii) unequal distribution of the chromosomes to the two poles (Fig. 11). The irregular separation and streching of chromosomes from one pole to other is an unique feature in *C. corymbosum*. Most commonly the entire spindle keeps covered with the chromosomes. Darlington (1938) described the occurrence of this type of chromosome behaviour due to asymmetrical nature of the trivalents in which the presence of three centromeres interferes with the normal orientation of compound bodies on the equator or it may be due to disparity (timing unbalance) between the activity of the spindle and centromeres. Sometimes this type of distribution may also be due to stickiness of the chromosomes and poor development of nuclear spindle. This irregular distribution of the daughter chromosomes over the spindle and later their unequal distribution to the poles results in the formation of micronuclei which vary in number from one to many (Fig. 12). Sometimes micronuclei also arise from metaphase univalents which fail to get included with other chromosomes at anaphase. Takenaka (1929); attributes their formation to stray chromosomes. Similar development of micronuclei has also been reported in *Allium schoenoprassum* (Leva, 1936); *Uvularia* (Barber, 1941); aegiotropic mutant of annual *teosinte* (Koul and Paliwal 1962); *C. diurnum* (Dubey and Singh, 1964) and *Pluchea lanceolata* (Koul, 1964). The size of micronuclei is variable depending upon the amount of chromatin involved. The pollen grain having these micronuclei are non viable. Microspore mother cells with normal meiosis showed regular formation of cell plates. Wall formation was of simultaneous type. Microspore tetrads thus formed were mostly tetrahedral only, rarely isobilateral. The viable pollen grains are spherical with thick and smooth exine and are shed at bicelled stage.

SUMMARY AND CONCLUSION

The cytology of *C. corymbosum* has been reported. Chromosome number has been found to be $2n=16$. In meiosis 8 bivalents were observed at diplotene, diakinesis and metaphase I, while at anaphase II chromatin bridges and laggards were also present In certain cells the chromosomes displayed stickiness and clumping. In some of the cases at diplotene chain of three chromosomes and a univalent were observed which have developed due to small terminal interchanges between non-homologous chromosomes. The second division showed chromatin bridges, irregular separation and distribution of daughter chromatins at telophase and formation of micronuclei at microspore stage. The present species is characterised by the presence of multivalents at and before metaphase, chromatin bridges and laggards at first and second anaphase and micronuclei. This indicates that the present species may be a structural hybrid. But before this could be concluded conclusively the study of some other species of *Cestrum* is essential.

The various irregularities in meiosis enumerated above seem to be responsible to a large extent for semisterility and poor seed set in *C. corymbosum.*

ACKNOWLEDGEMENTS

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LITERATUTE CITED

1. Anonymous. 1950. "The wealth of India." C. S. I. R., New Delhi.
2. Barber, H. N. 1941. Chromosome behaviour in *Uvularia*. *Jour. Genetics.*, **42**: 223-257.
3. Beadle, G. W. 1932. A gene for sticky chromosome in *Zea mays*. *Zeits. i. Abst. u. Vereb.*, **63**: 195-217.
4. Beadle, G.W. 1937. Chromosome Aberration and gene mutation in sticky chromosome plant of *Zea mays*. *Cytologia. Fujii. Jub.*, **23**: 43-56.

5. Bhaduri, P. N. 1933. Chromosome number of some solanaceous plants of Bengal. *Jour. Ind. Bot. Society*, **12**:54-64.

6. Bhaduri, P. N. & Kar, A. K. 1948. Study of chromosome nucleolus relationship and its bearing on interpretation of *Oenothera* cytogenetics. *Bull. Bot. Soc. Bengal*, **2**:1-14.

7. Blakeslee, A. F. 1928. Genetics of *Datura*. Verh. V. Int. Kongr. Verebur gs wiss 1927 (Berlin) **1**:117-130.

8. Burnham, C. R. 1962. "Discussions in Cytogenetics" Burgess Publishing Company, Minneapolis 15, Minnesota.

9. Darlington, C. D. & Wylie, A. P. 1950. Chromosome atlas of Flowering plants. George Allen & Unwin, London.

10. Dubey, R. S. & Singh, S. P. 1964. Cytological studies on *Cestrum diurnum*. (in press).

11. Hakansson, A. & Levan, A. 1942. Nucleolar condition in *Pisum*. Hereditas, **28**:436-440.

12. Koul, A. K. & Paliwal, R. L. 1962. An aegiotropic mutant of annual *Teosinte* and cytological behaviour. *Agra Univ. Jour. Res.* (*Sci.*), **X**:79-89.

13. Koul, A. K. 1964. Morphological and cytological studies of *Pluchea lanceolata*, a common weed of tropics. Caryologia, **17** (2): 433-451.

14. Levan, A. 1936. Zytologische studien on *Allium kamtrchaticum* Pall. VI. On the nucleolus chromosome relationship. *Cytologia.*, **9**:56.

15. Takenaka, Y 1929. Karyological studies in *Hemerocallis*. *Cytologia*, **1**:76.

16. Tandon, S. L. & Kapoor, B. M. 1961. Nucleolar number and polyploidy level. *Curr. Sci.*, **30**:476-477.

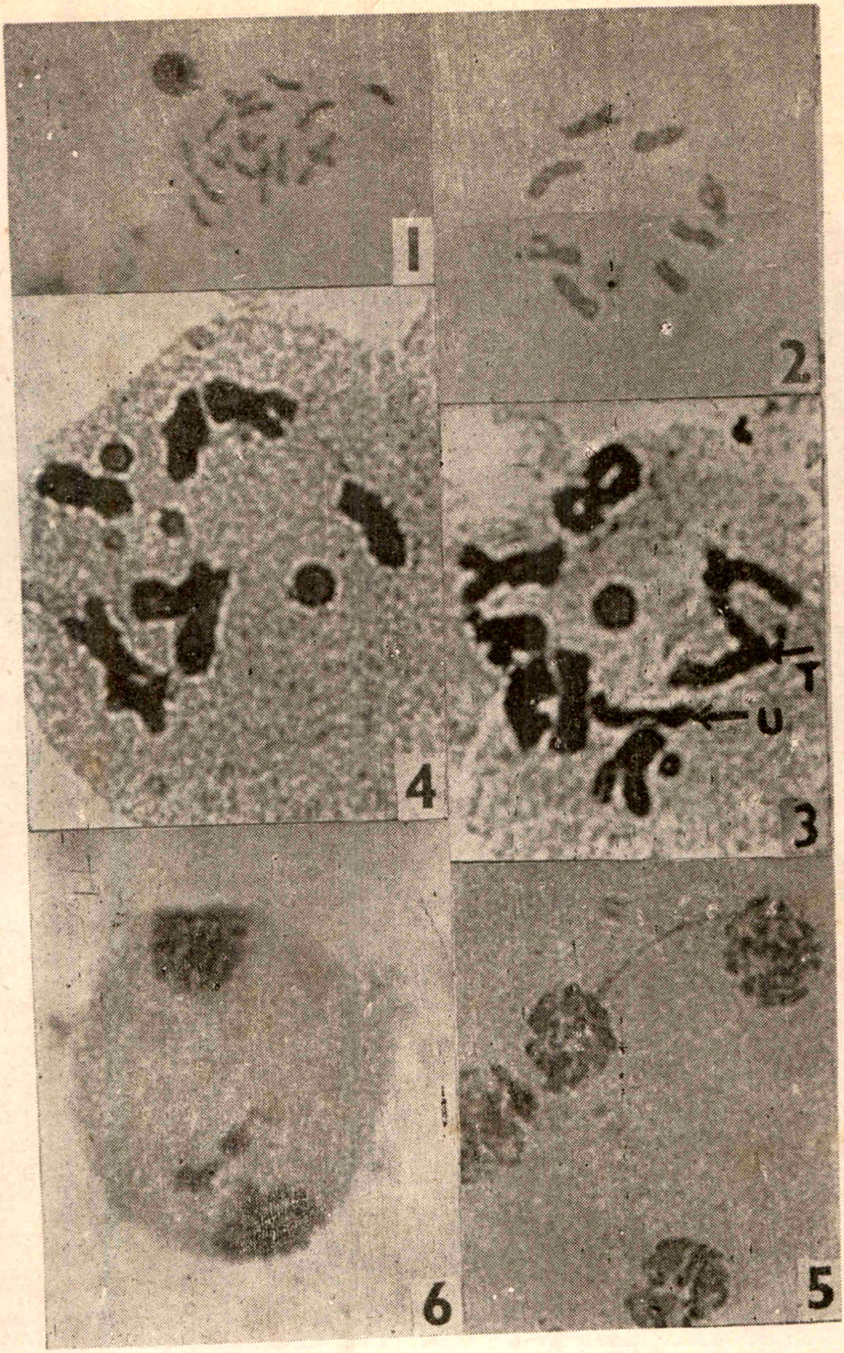

Plate No. 1

Figs. 1-6. Meiosis in *Cestrum corymbosum*.
Figs. 1 & 2. × 700. Figs. 3-6, × 1400.
Fig. 1. Mitotic metaphase in the anther wall cells. 2n=16.
Fig. 2. Diplotene showing 8 II
Fig. 3. Diplotene showing 6 II 1 III 1 I. Also note two nucleoli.
Fig. 4. Diplotene showing 8 II and 4 nucleoli.
Fig. 5. Anaphase I showing a chromatin bride.
Fig. 6. Anaphase I showing two laggards.

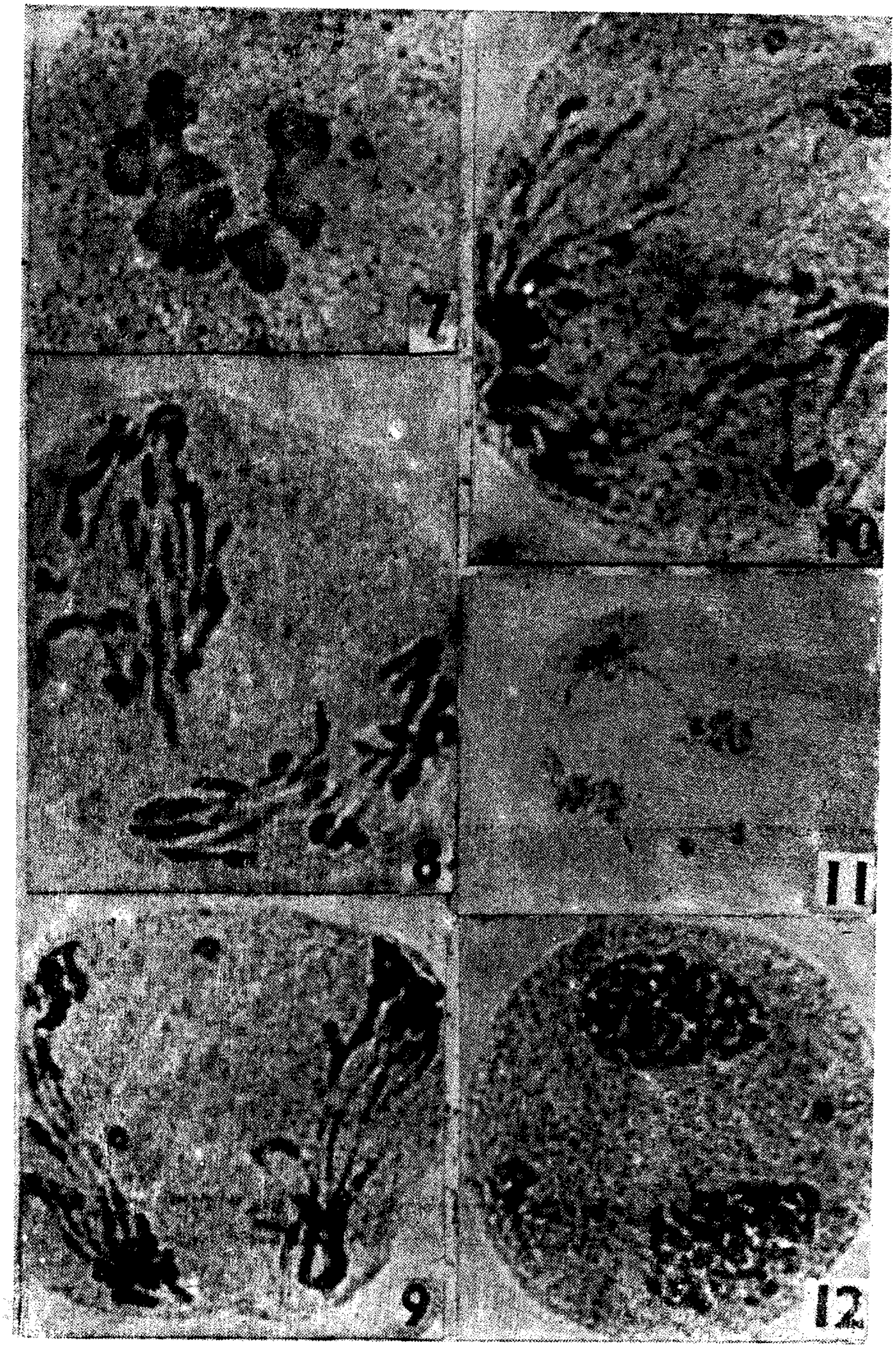

Plate No. 2.

Figs. 7-12. Meiosis and microspore formation in *C. corymbosum*.
Figs. 7 & 8, 10-12, × 1400. Fig. 9, × 700.
Fig. 7. Metaphase I showing chromosomes clumped to form a single mass.
Fig. 8. Anaphase II showing irregular separation of daughter chromosomes.
Fig. 9 & 10. Anaphase II showing irregular distribution of chromatin material between the two poles.
Fig. 11. Anaphase II showing chromatin bridge. Also note chromatin fragments.
Fig. 12. A sporogenous cell after second division showing four nuclei of varying sizes.

Abbreviations :—
T=trivalent.

STUDY ON THE RELATIONSHIP BETWEEN CLEAN WOOL FROM THE SMALL REGIONAL SAMPLES AND THE WHOLE FLEECE IN 'MAGRA EWES'*

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A breeder is always interested only in rearing a flock which may give the maximum profit. The production is affected by many factors. Proper and judicious breeding is one of them. Selection of better and culling of poorer is the proper tool for bringing the improvement in livestock productivity. In selection of sheep necessary emphasis must be given on the amount of clean wool produced by an individual. To determine the clean wool yield from a sheep is a cumbersome process and also a time consuming one. Consequently a quick process to estimate clean wool yield is a must. This is possible if a correlation is determined between the whole clean-wool yield and small portions drawn from different parts of the body. The part which gives the highest correlation will serve to predict clean wool yield from the whole body surface. Some of the workers such as Pohle and Hazel (1944), Schott et al., (1916), Morley, et al., (1955), Sugai and Nagasawa (1957) and Mahal and Kumar (1959) have, however, reported the correlation between regional samples and the whole clean fleece yield in different breeds of sheep. No such information, however, is available for 'Magra' sheep. It was, therefore, planned to study the relationship between five regional samples and the whole clean fleece weight for this important breed which is famous for the carpet wool production in India.

EXPERIMENTAL

Forty stall-fed 'Magra' ewes were selected from a flock maintained at R. B. S. College, Khandari Farm, Agra. The ewes were approximately similar in age and body weight. Three clips were taken during the year 1964 viz., spring, *Monsoon* and Autumn. For the present study only latter two clips were used.

All the ewes were washed one day before shearing. On the day of shearing each ewe was restrained on a clean *pucca* floor. The samples of wool were clipped with a fine pair of scissors close to the skin from the delineated area (4 square inches) of different body regions viz., shoulder, wither, loin, mid-side and britch (Plate No. 1). These samples were taken from both sides of the body. The clipped samples were kept in bags with all their details and then transferred to laboratory to await the analysis.

After sampling, the ewes were shorn as usual and the raw fleece weight was recorded. The individual fleece was kept in a weighed moisture proof polythene bag which was properly sealed with a slip inside carrying all the details about it. Such sealed bags were transferred to store room till needed for analysis.

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* Contribution No. A.H. & D. 112/R 69/AS 45.

† PL-480 Goat Scheme.

The clean wool yield in the raw wool was determined following the technique recommended by I.S.I (1959).

RESULTS AND DISCUSSION

The clean wool yield was estimated from five regional samples and the whole fleece of 'Magra' ewes. The correlation and regression coefficients between the individual regional small wool samples and the whole fleece were calculated, for both *Monsoon* as well as Autumn clips, 1964. The mean values of the clean wool yield from the regions and the whole body alongwith their statistical analysis are presented in table 1.

TABLE 1

Average clean wool yield (gm.) from the regional small wool samples and the whole fleece alongwith their correlation and regression co-efficients and calculated 't' value for the clips under study.

Clips	Regional small samples	Whole fleece	Correlation coefficient (r)**	Regression coefficient (Byx)*	Calculated 't' value
Monsoon	*Shoulder* 6·48±0·30	526·36±24·3	0·96	72·43	21·94
Autumn	4·97±0·24	388·76±21·1	0·99	79·43	58·61
Monsoon	*Wither* 9·04±0·50	526·36±24·3	0·87	42·81	10·71
Autumn	6·94±0·34	388·76±21·1	0·97	58·31	23·68
Monsoon	*Loin* 8·61±0·44	526·36±24·3	0·86	46·40	9·86
Autumn	6·52±0·34	388·76±21·1	0·97	56·66	23·37
Monsoon	*Mid-side* 5·54±0·24	526·36±24·3	0·91	87·18	12·94
Autumn	4·20±0·22	388·76±21·1	0·98	84·91	29·01
Monsoon	*Britch* 6·63±0·31	526·36±24·3	0·95	70·31	10·47
Autumn	5·11±0·80	388·76±21·1	0·98	82·56	29·01
Monsoon	*Average of the five regions* 7·26±0·36	526·36±24·3	0·86	57·48	9·86
Autumn	5·53±0·37	388·76±21·1	0·95	66·99	17·76

** Significant ($P<0·01$).

* X-Clean wool yield from the regional small samples.
Y-Whole clean fleece weight.

Shoulder : The data (Table 1) indicate that correlation between clean wool yield of shoulder region and the whole clean fleece weight was found to be highly significant for both, *Monsoon* ($r=0{\cdot}96$) as well as Autumn ($r=0{\cdot}99$) clips. The regression lines (Figs. 1 and 2) show 72·43 and 79·43 gm increase or decrease in the average whole clean fleece weight for every one gm. of clean wool yield from the shoulder area in *Monsoon* and Autumn clips respectively. The equations given below can be used to predict the whole clean fleece weight with the help of clean wool yield from shoulder region (4 sq. inches) for both the clips.

Monsoon Clip — $Y=72{\cdot}43x+57{\cdot}02$

Autumn Clip — $Y=79{\cdot}43x+5{\cdot}73$

Y—Whole clean fleece weight

X—Clean Wool Yield from the regional small samples

The present findings for both the clips are in agreement to those of Mahal and Kumar (1959) who have also reported that a single shoulder wool sample can be used to predict the whole clean fleece weight in Bikaneri sheep. Sugai and Nagasawa (1957) have, however, recorded a poor correlation ($r=0{\cdot}31$) between shoulder sample and the whole fleece in corriedale sheep.

Wither : The correlations of the small sample from this area with the whole fleece in Monsoon ($r=0{\cdot}87$) and Autumn ($r=0{\cdot}97$) clips were slightly lower than those of the shoulder samples but highly significant. The regression lines (Figs. 3 and 4) indicate 42·81 gm. and 58·31 gm. increase or decrease in whole clean fleece weight for every one gm. of Wither-clean wool in both *Monsoon* and Autumn clips respectively. The equations to estimate the whole clean fleece weight from the wither-clean wool yield are given as follows :

Monsoon Clip—$Y=42{\cdot}81x+138{\cdot}51$

Autumn Clip—$Y=58{\cdot}31x+14{\cdot}69$

Loin : The coefficients of correlation between the clean wool yield of this region and the whole clean fleece weight for both the clips were similar to those of wither region. From the regression lines (Figs. 5 and 6) it is seen that for every one gm. of clean wool yield from this region, an increase or decrease of 46·40 and 56·66 gm. of whole clean wool yield may be recorded in *Monsoon* and Autumn clips respectively. The equations to predict the entire clean wool yield from the loin small clean wool sample are mentioned below:

Monsoon Clip—$Y=46{\cdot}40x+126{\cdot}86$

Autumn Clip—$Y=56{\cdot}66x+19{\cdot}61$

Mid-side : The average clean wool yield (Table 1) from mid-side samples shows the lowest standard error in both *Monsoon* ($\pm 0{\cdot}24$) and Autumn ($\pm 0{\cdot}22$) clips as compared to rest of the regional samples. Thus, it indicates a close uniformity in clean wool production from this region. The coefficients of correlation for *Monsoon* (r = 0·91) and Autumn (r = 0·98) clips are also encouraging. The regression lines (Figs. 7 and 8) indicate 87·18 and 84·91 gm. increase or decrease in the average whole clean fleece weight for each one gm. of mid-side clean wool in *Monsoon* and Autumn clips respectively. The equations to predict the whole clean fleece are as under :

Monsoon Clip—$Y = 87{\cdot}18x + 43{\cdot}39$

Autumn Clip—$Y = 84{\cdot}91x + 32{\cdot}42$

Britch : The wool samples from this region showed correlation coefficients as r = 0·95 and r = 0·98 for *Monsoon* and Autumn clips respectively. The regression lines (Figs. 9 and 10) exhibited an increase or decrease of 70·31 and 82·56 gms. in whole fleece for each gm. of britch wool in *Monsoon* and Autumn clips respectively, The equations to predict the whole fleece weight are as follows :

Monsoon Clip—$Y = 70{\cdot}31x + 60{\cdot}21$

Autumn Clip—$Y = 82{\cdot}56x + 32{\cdot}85$

Average of the five regional samples: The correlation coefficients of these samples for monsoon (r = 0·86) and Autumn (r = 0·95) clips are almost similar to those of loin region and slightly less than those of the rest regional samples. The regression lines (Figs. 11 and 12) show an increase or decrease of 57·48 and 66·99 gm. of whole clean fleece for each gm. of composite regional clean wool. The equations to predict the whole clean fleece are mentioned below:

Monsoon clip—$Y = 57{\cdot}48x + 108{\cdot}49$

Autumn clip—$Y = 66{\cdot}99x + 18{\cdot}57$

From these data (Table 1) it is perused that small wool sample from any one of the five region or a composite sample from all these regions may be used to predict the whole clean fleece weight with the help of corresponding equation. From the study of correlation coefficients for both the clips it is seen that in order of preference shoulder is most suitable region followed by britch, mid-side, wither, loin and average of all these five regions. Similarly Mahal and Kumar (1959) and Sugai and Nagasawa (1957) have respectively reported shoulder and britch as the most suitable regions in Bikaneri and corriedale sheep for this purpose. However, Beattzi and Chapman (1956) have recommended mid-side region a most convenient site in Merino ewes for such prediction.

Relationship between the clean wool yield percentage of the regional small samples and the whole fleece

Frequency distribution: From the raw as well as the clean wool yield data, clean wool yield percentages for the regional samples and the whole fleece were calculated. In order to judge a regional sample representative of the whole fleece in respect of clean wool yield percentage, the frequency distribution of the individual figures obtained for each region and the whole body was statistically studied. The frequency distribution of these data for both the clips is shown in table 2.

TABLE 2

Frequency distribution of the clean wool yield percentage for each region and the whole body during Monsoon and Autumn Clips.

Class Intervals	Shoulder		Wither		Loin		Mid-side		Britch		Whole body	
	M	A	M	A	M	A	M	A	M	A	M	A
Below 77	2	0	5	0	3	0	3	1	6	1	0	0
77–79	2	0	0	0	1	0	4	0	8	0	4	1
79–81	6	2	2	0	6	2	10	1	9	0	9	2
81–83	7	2	2	0	7	1	5	1	2	4	10	2
83–85	5	3	10	1	6	1	7	2	1	5	3	2
85-87	4	2	7	3	6	3	0	1	3	15	5	1
87–89	4	6	3	2	3	3	3	12	3	4	4	11
89–91	2	11	1	5	2	14	6	13	3	6	2	8
91–93	2	6	7	15	2	6	1	3	1	3	1	7
93–95	3	5	0	11	2	4	1	3	1	2	0	4
Above 95	3	3	3	3	2	6	0	3	3	0	2	2
Total	40	40	40	40	40	40	40	40	40	40	40	40
Percentage showing the frequency between 79 to 85 & 87 to 93 in M & A clips respectively.	45·0	62·1	35·0	51·3	47·5	59·4	55·5	72·9	30·0	32·4	55·0	70·2

M=Monsoon Clip, A=Autumn Clip.

Table 2 indicates that maximum frequency for clean wool yield percentage was observed between 79 to 85 and 87 to 93 in *Monsoon* and Autumn clips respectively. A study of the frequency distribution within the same limit of clean wool yield percentages for both the clips reveals that mid-side region corresponds almost parallel to the whole body. Thus, it indicates that this region is a suitable site to represent the whole body in respect of clean wool yield percentage.

Average clean wool yield percentages : The average clean wool yield percentage for each region, collectively from all regions and of the whole fleece were calculated and statistically analysed. The average values alongwith their S.E. and coefficients of variance are presented in table 3.

TABLE 3

Relationship between the average clean wool yield percentages of regional samples and the whole fleece for the two clips.

Regions	Average clean wool yield percentage during two clips			Coefficient of variance duri two clips		
	M—64	A—64	Mean of both the clips	M—64	A—64	Mean o the
Shoulder	85·30±2·30	90·10±0·57	87·70±1·75	17·35	3·97	8·
Wither	85·14±2·40	91·90±0·60	88·52±1·69	18·44	4·05	9·
Loin	84·40±1·02	91·10±0·70	87·76±0·98	7·70	4·67	6·
Mid-side	82·90±0·99	89·10±0·86	86·00±0·89	7·59	6·56	6·
Britch	82·40±1·40	85·90±0·76	84·15±0·87	11·07	5·27	8·
Average of all the five regions	84·03±1·68	89·62±0·79	86·83±0·91	10·12	4·92	7·
Whole fleece	83·70±1·31	89·70±0·71	86·70±0·88	7·63	5·87	6·

M—Monsoon, A—Autumn.

The data (Table 3) show that when the average clean wool yield centages for both the clips are considered, the mean value for the averag all the five regional wool samples is the nearest approach for the whole f (86·83 Vs. 86·70). Among the individual regional samples, mid-side again been found to be a better representative of the whole fleece.

From these findings it may be inferred that among the regions, mid is the most suitable site for collecting a small wool sample to predict the c wool yield percentage of the whole fleece. Similarly Singh et al., (1964) also reported the same region a representative one of the whole fleece in re of the wool characteristics.

SUMMARY

In order to determine a suitable site for the collection of small sample from which to predict the whole clean fleece weight and its clean yield percentage, the relationship between the small regional samples anc whole fleece was studied.

Forty stall-fed 'Magra' ewes were selected for the experiment. Small samples from five regions viz., shoulder, wither, loin, mid-side and britch the whole fleece were taken in *Monsoon* and Autumn clips-1964 for this study.

The correlation coefficients between shoulder, wither, loin, mid-side britch samples, average of all the five regional samples and the whole f were respectively recorded to be 0·96, 0·87, 0·85, 0·91, 0·95 and 0·8 *Monsoon* and 0·99, 0·97, 0·97, 0·98, 0·98 and 0·95 in Autumn clips. The cor tion values for both the clips were highly significant ($P<0·01$) which dep

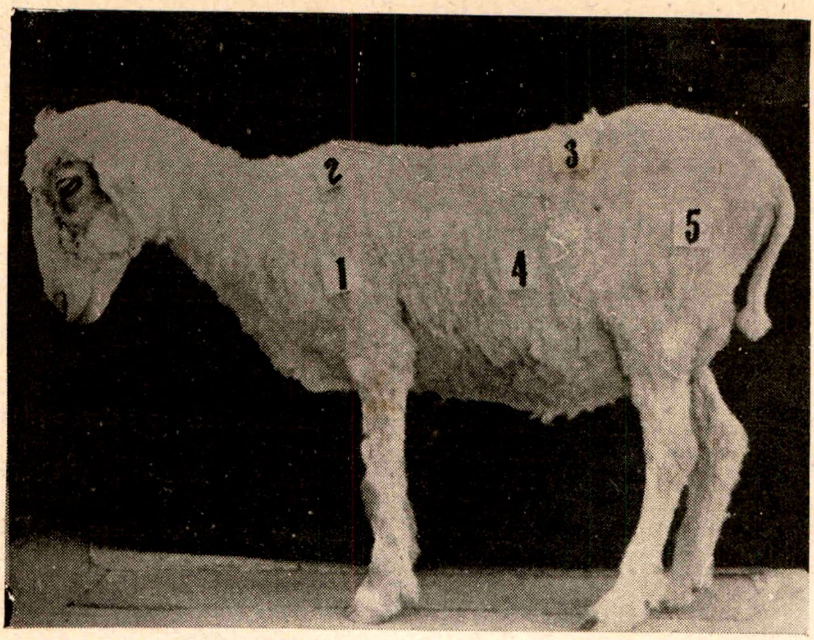
that small wool sample from any one of the five regions may be taken to predict the whole clean fleece weight. However, among the regions shoulder was found to be most suitable.

The mean clean wool field percentages for both the clips were estimated as 87·70±1·75, 88·52±1·69, 87·76±0·98, 86·00±0·89, 84·15±0·87, 86·83±0·91 and 86·70±0·88 respectively for shoulder, wither, loin, mid-side, britch, pooled sample from five regions and the whole fleece. The mean value of the pooled regional wool sample was found to be the nearest approach for the whole fleece (86·83 Vs 86·70%). Among the regions, mid-side proved to be a most suitable site for taking the small wool sample to predict the clean wool yield percentage of the whole fleece.

REFERENCES

1. Beattie, A.W. & Chapman, R.E. 1956. "Sampling fleeces to estimate yield of clean wool" *Qul. J. Agri. Sci.*, **13**:13-18.
2. I.S.I. Bulletin. 1959. "Method for determination of clean wool yield of raw wool." The Catholic Press, Ranchi, India.
3. Mahal, G.S. & Kumar, S. 1959. "Estimation of clean fleece yield from small regional samples in the fleece of Bikaneri sheep." *Indian J. Vet. Sci. & A.H.* **29**: 73-79.
4. Morley, F.H.W., Lockart, L.W. & Devi, E.C. 1955. The value of production from a clipped measured area as an index of fleece weight" *Aust. Jt. Agri. Res.*, **6**: 91-98.
5. Pohle, E.M. & Hazel, I.N. 1944. Clean Wool Yield in small samples from eight body regions as related to whole fleece yields in four breeds of sheep" *J. Anim. Sci.*, **3**: 150-165.
6. Schott, R.G., Pohle, E.M., Spencer, D. A. & Brier, G. W. 1946. Wool yield in the small side sample as related to individual whole fleece yields in four breed groups of sheep" *J. Anim. Sci.* **5**: 137-144.
7. Singh, J.P., Singh, G. S. & Singh, S. N. 1964. A Study in variability in the quality of wool on different regions of the fleece of 'Magra' sheep" *Agra Univ. J. Res.* (*Sci.*), **XIII** (2): 161-180.
8. Sugai, X. & Nagasawa, H. 1957. Studies on the wool yield of Sheep-II. on clean wool yield. Variations among body regions and prediction of clean wool yield of the entire fleece of the Corriedale sheep." Abstracted in Anim. Breed. Abstr. 1960, 26:173.

PLATE—I



Showing the regional sample site
1. Shoulder, 2. Wither, 3. Loin,
4. Mid-side, 5. Britch.

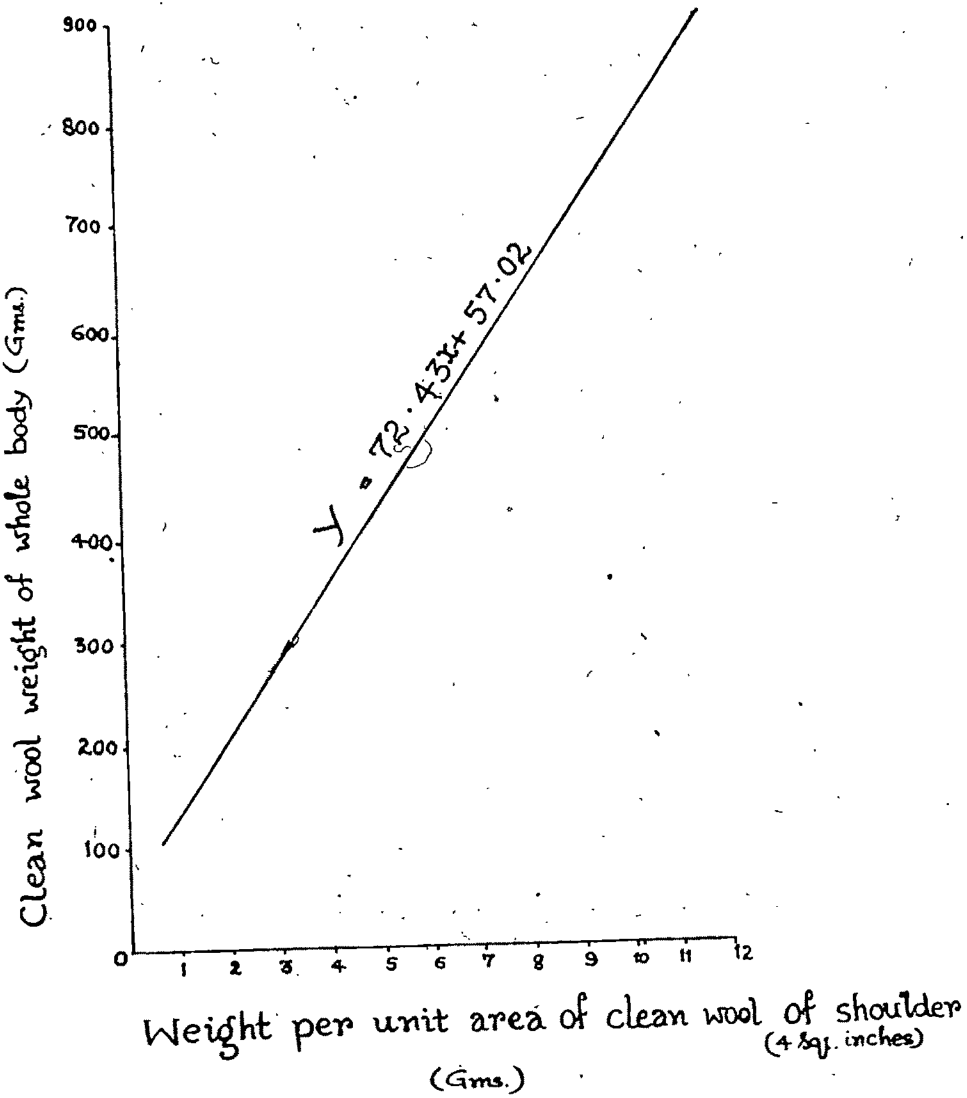


Fig. 1. Regression line showing the relation between the clean wool yield (Gms.) of the shoulder area (4 sq. inches) and the wohle body in Monsoon Clip.

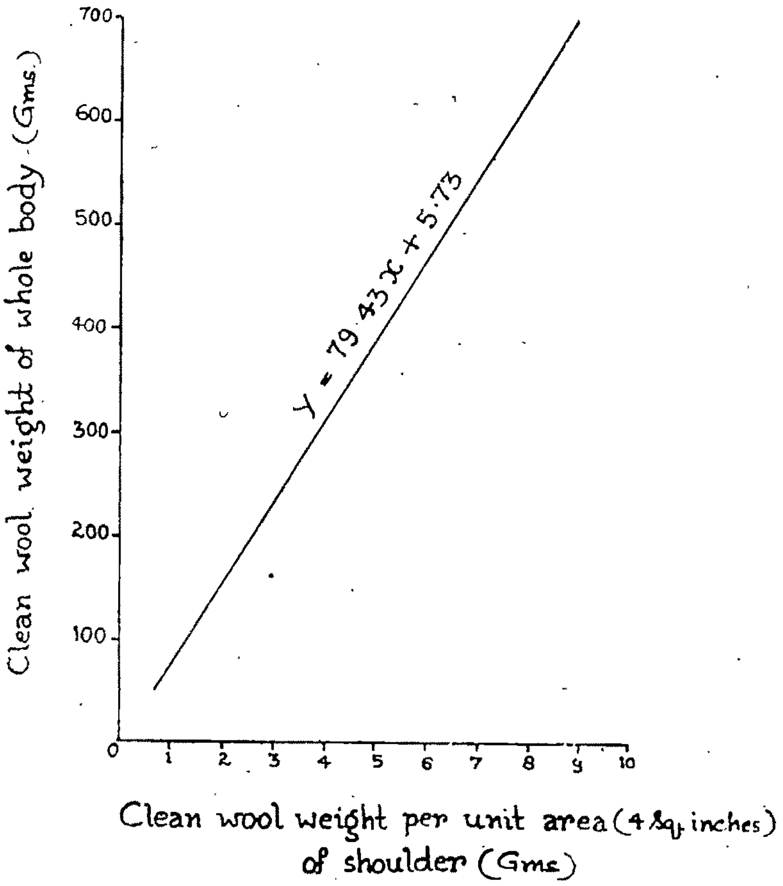


Fig. 2. Regression line showing the relation between the clean wool yield (Gms.) of the shoulder area (4 Sq. inches) and the whole body in Autumn Clip.

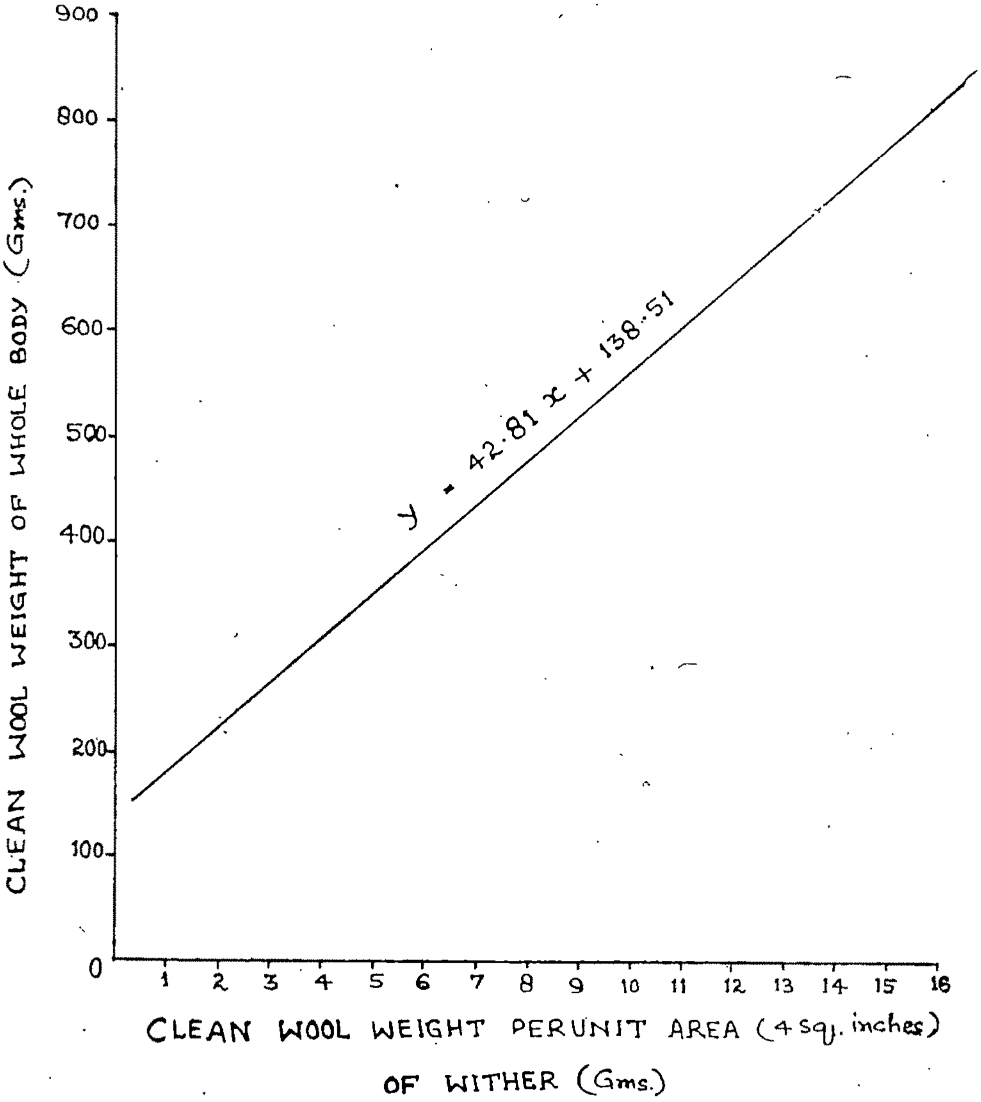


Fig. 3. Regression line showing the relation between the clean wool yield (Gms.) of the wither area (4 Sq. inches) and the whole body in Monsoon Clip.

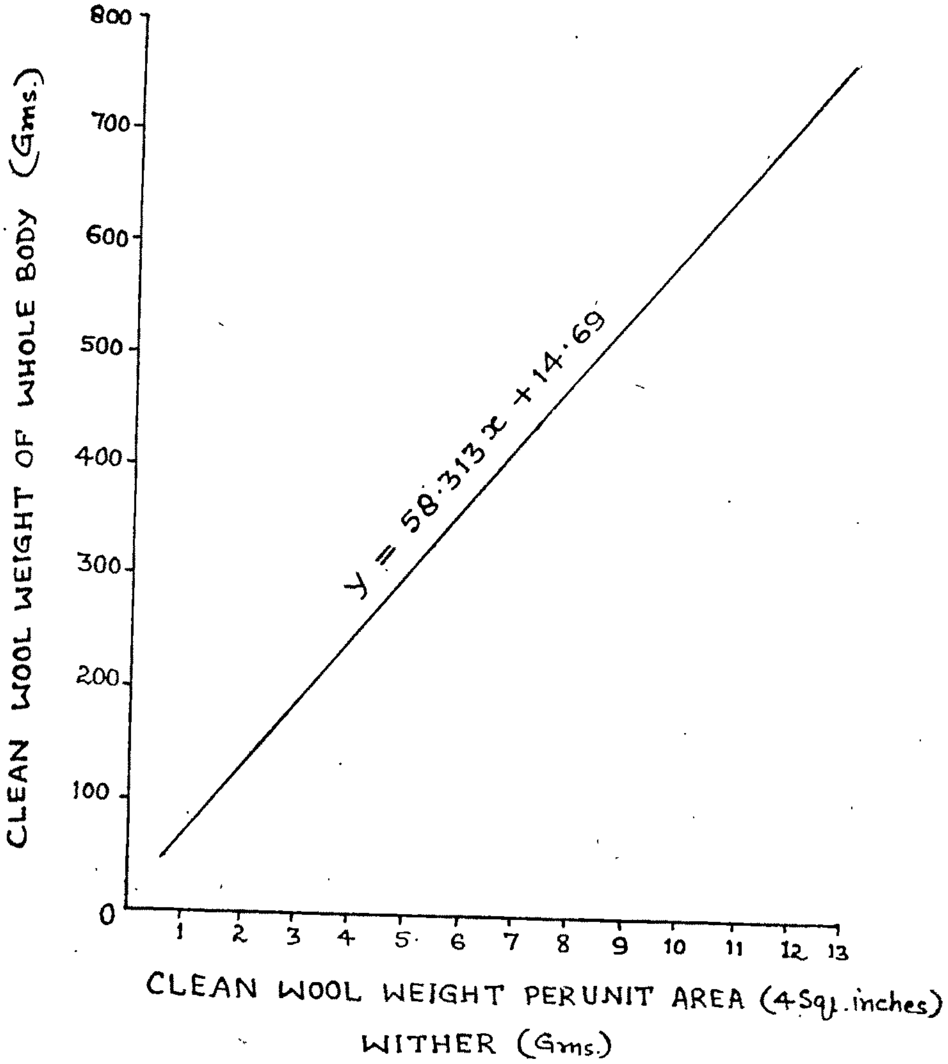


Fig. 4. Regression line showing the relation between the clean wool yield (Gms.) of the wither area (4 Sq. inches) and the whole body in Autumn Clid

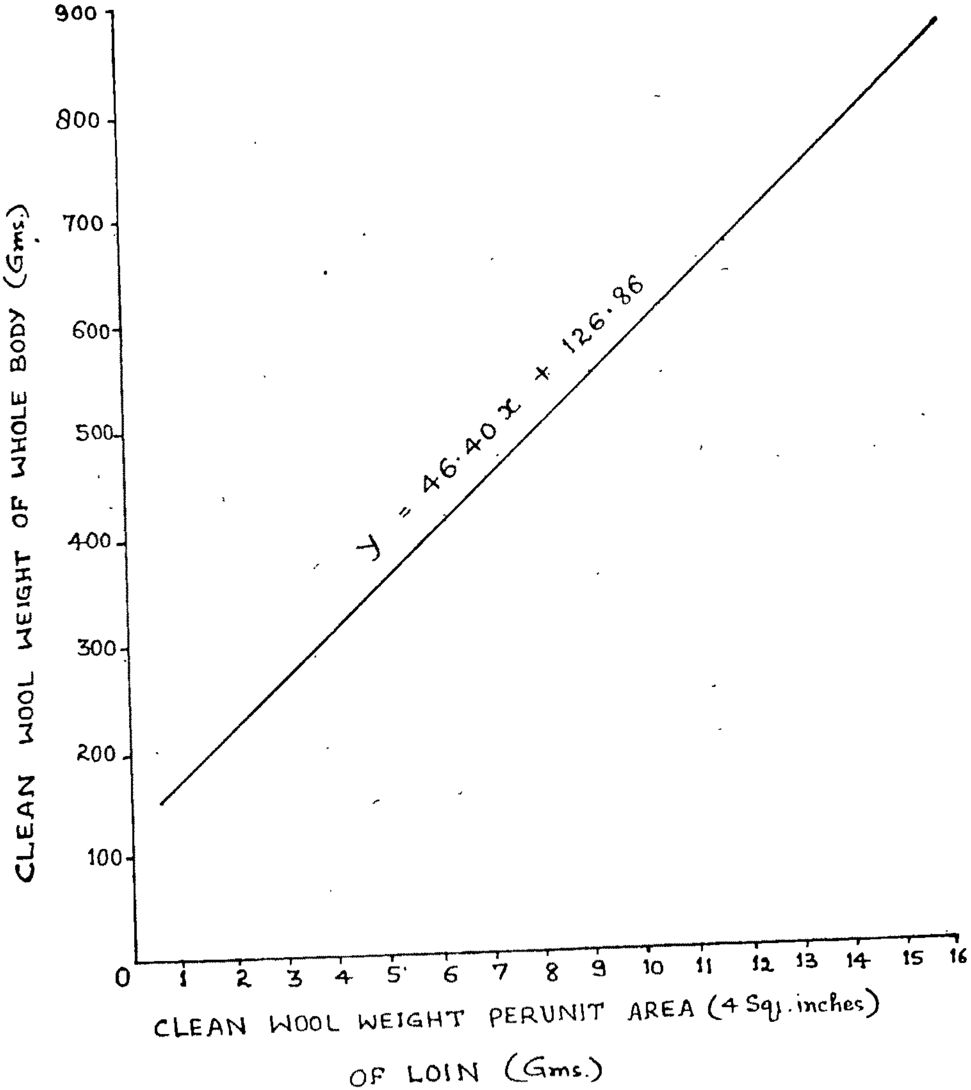


Fig. 5. Regression line showing the relation between the clean wool yield (Gms.) of the loin area (4 Sq. inches) and the whole body in Monsoon Clip.

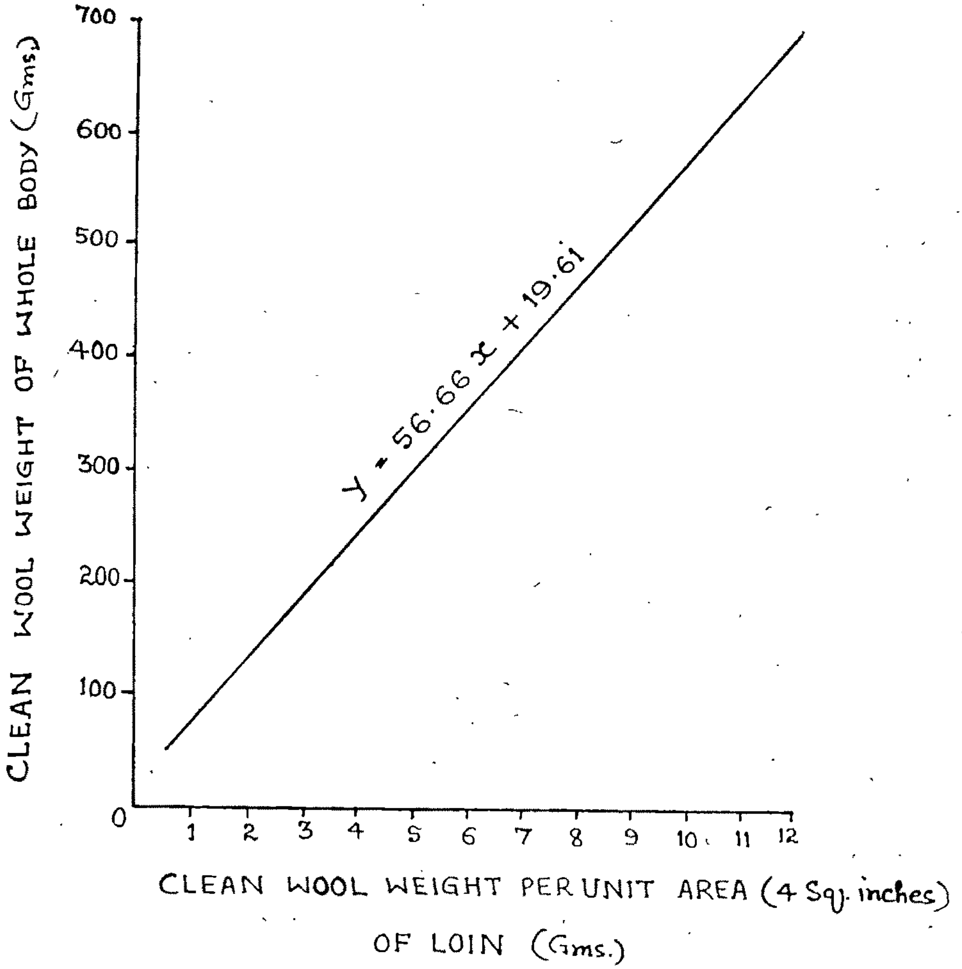


Fig. 6. Regression line showing the relation between the clean wool yield (Gms.) of the loin area (4 Sq. inches) and the whole body in Autumn Clip

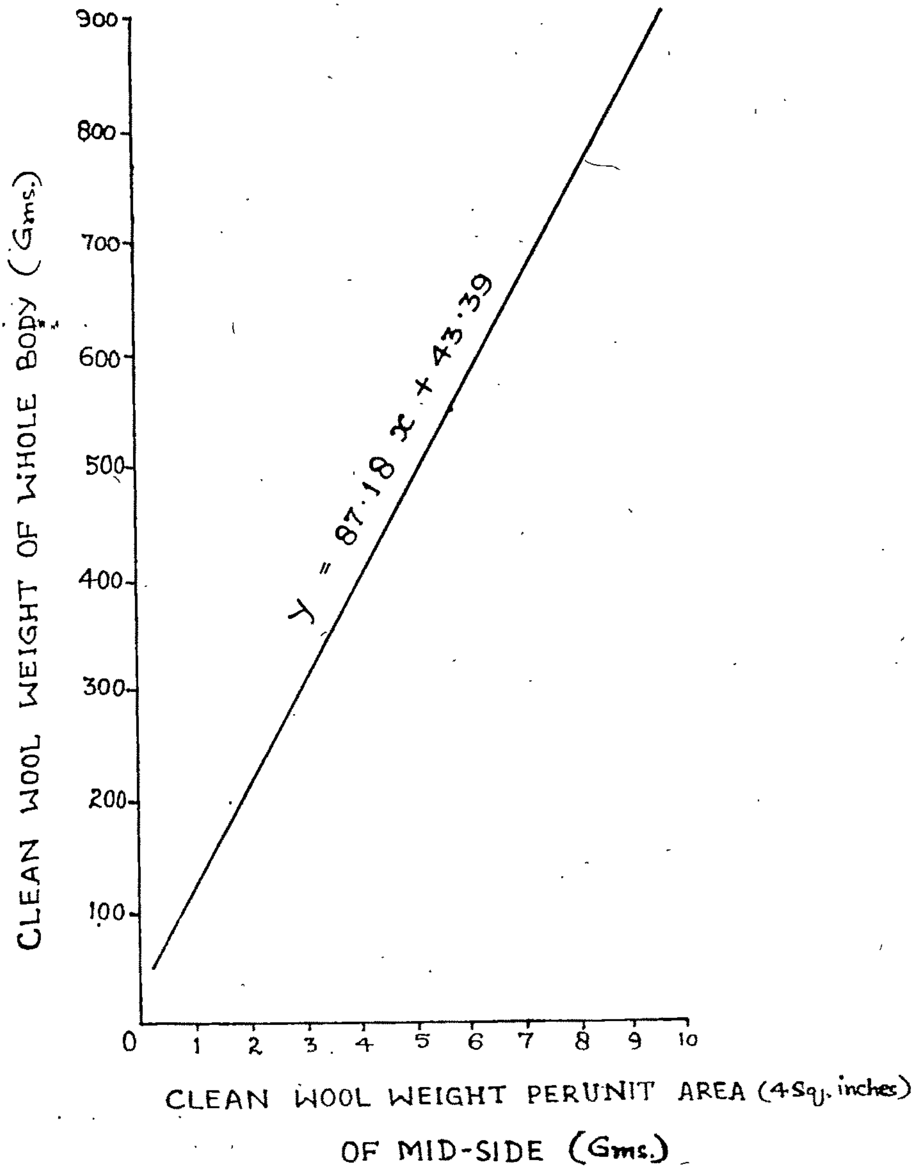


Fig. 7. Regression line showing the relation between the clean wool yield (Gms.) of the mid-side area (4 Sq. inches) and the whole body in Monsoon Clip.

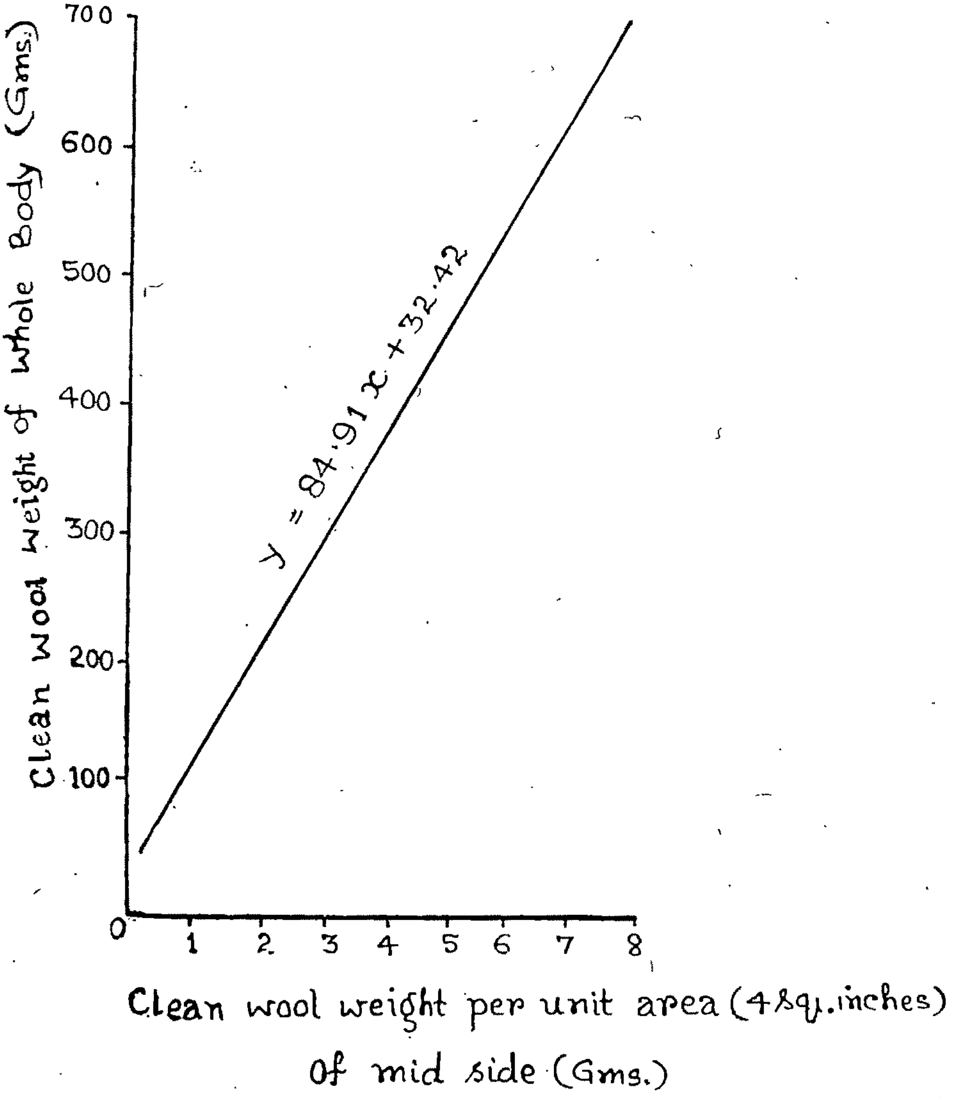


Fig. 8. Regression line showing the relation between the clean wool yield (Gms.) of the mid side area (4 Sq. inches) and the whole body in Autumn Clip.

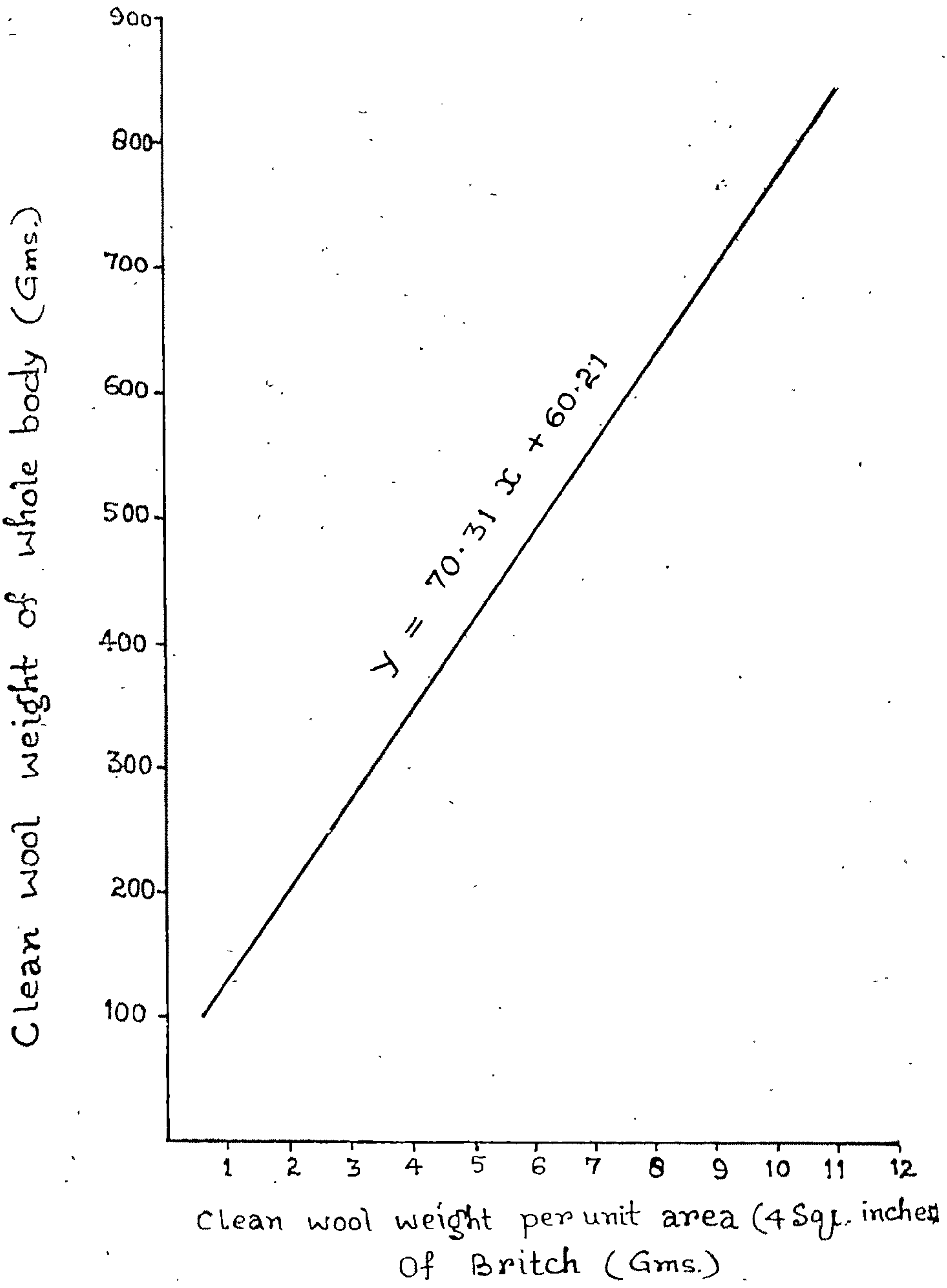


Fig. 9. Regression line showing the relation between the clean wool yield (Gms.) of Britch area (4 Sq. inches) and the whole body in Monsoon Clip.

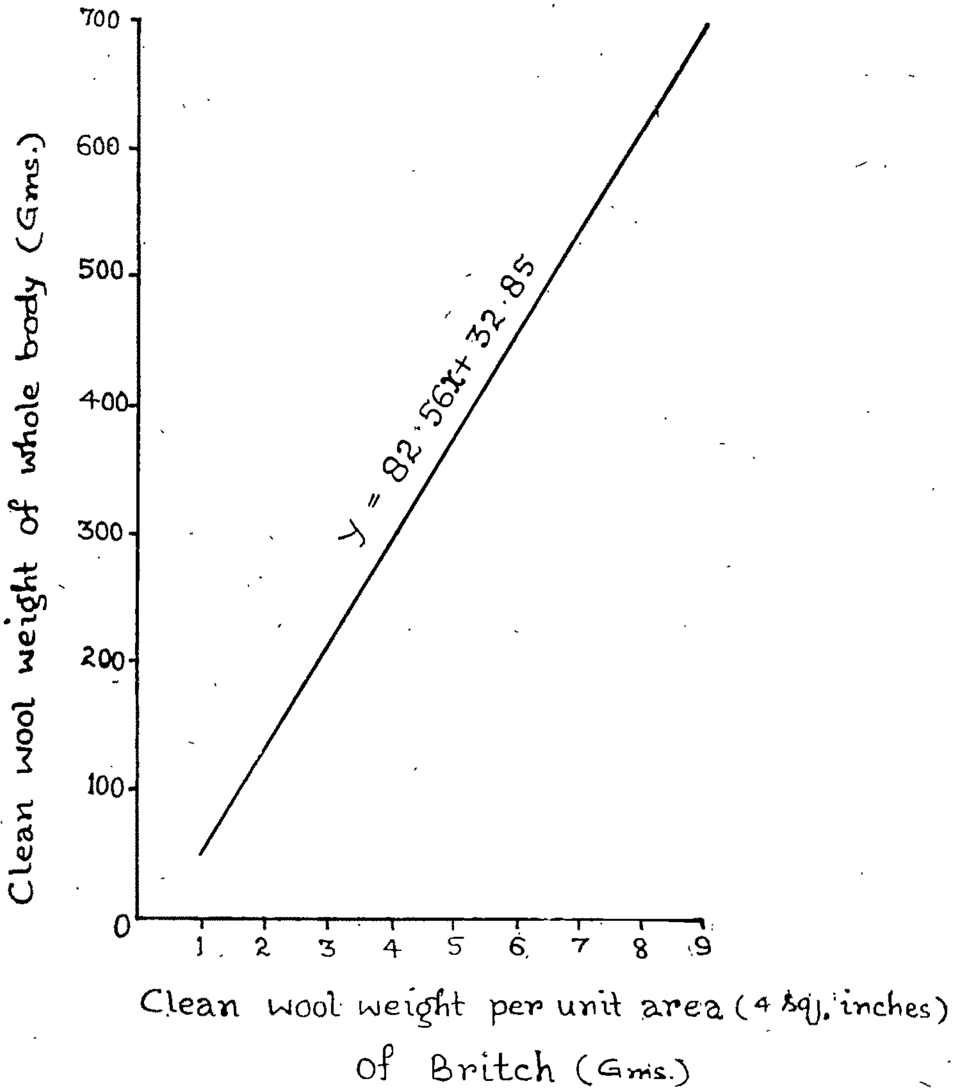


Fig. 10. Regression line showing the relation between the clean wool yield (Gms,) of Britch area (4 Sq. inches) and the whole body in Autumn Clip.

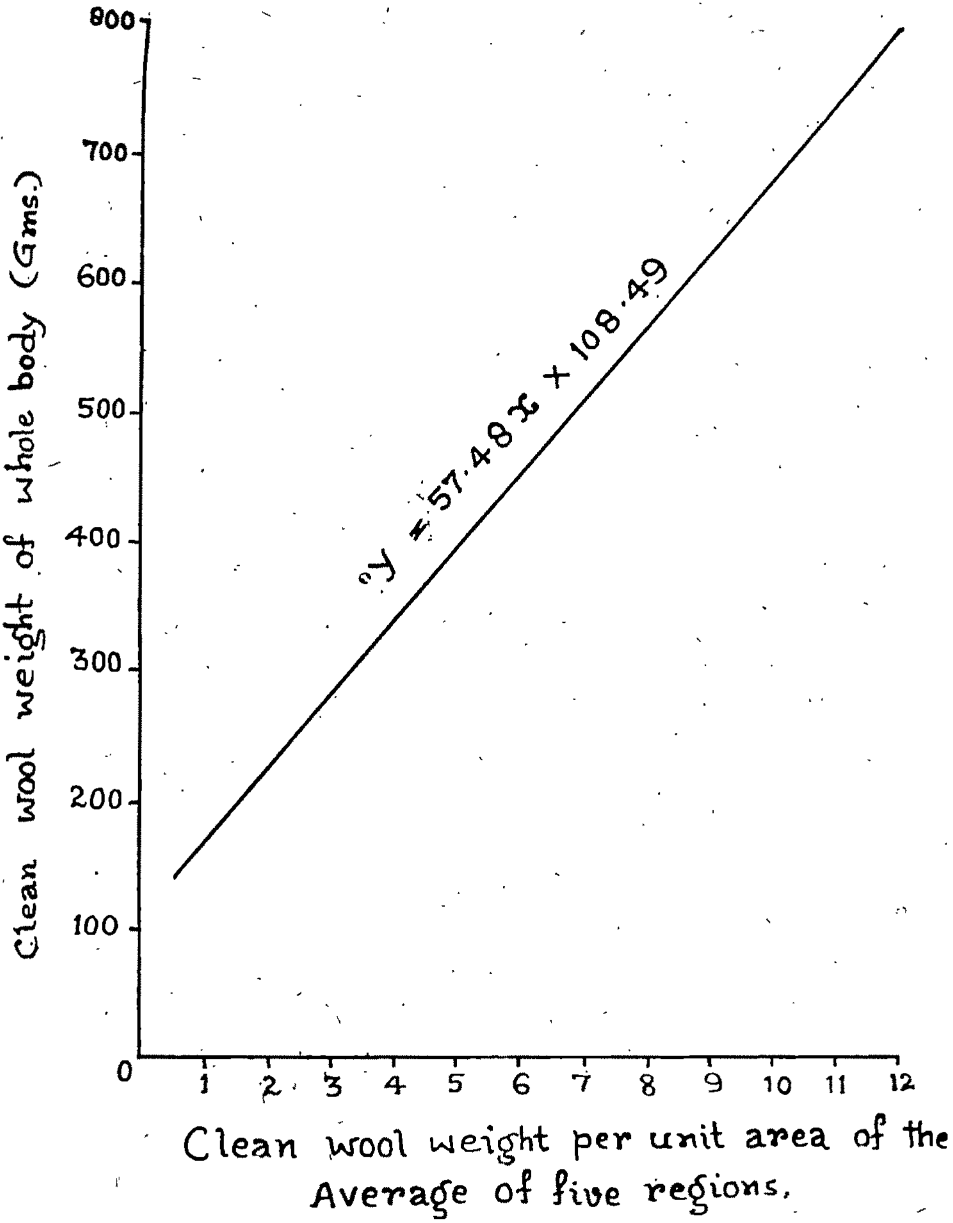


Fig. 11. Regression line showing the relation between clean wool yield (Gms.) of the average of five regions and the whole body in Monsoon Clip.

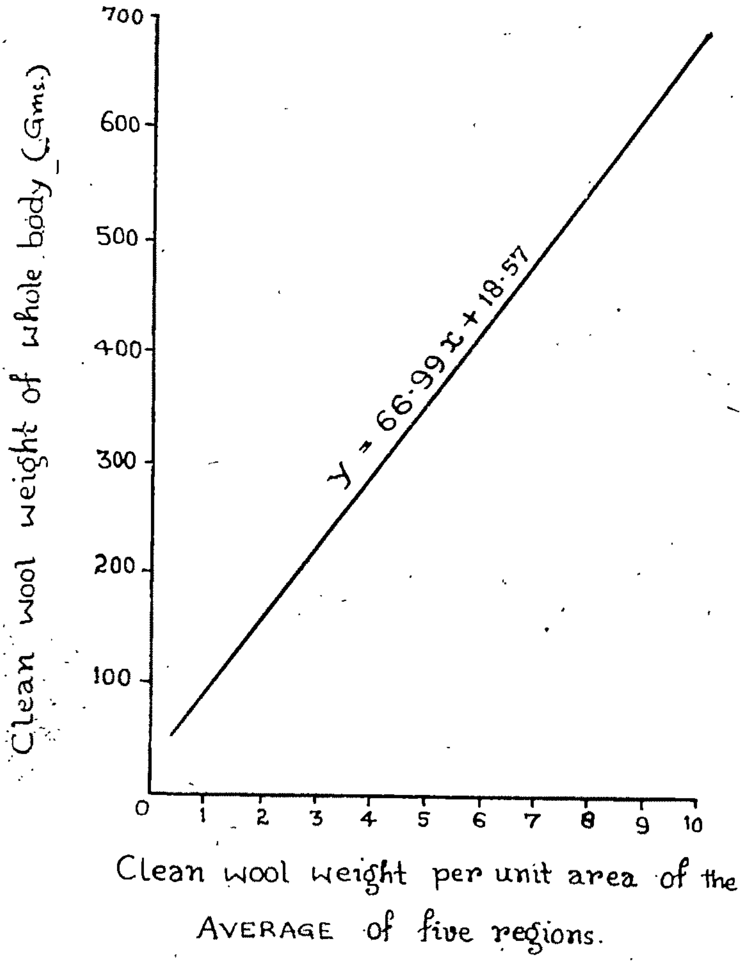


Fig. 12. Regression line showing the relation between the clean wool yield (Gms.) of average of five regions and the whole body in Autumn Clip.

STUDIES ON THE FLORAL BIOLOGY OF IMLI (*TAMARINDUS INDICA* Linn.)

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Imli or Tamarind, (*Tamarindus indica* Linn.) a member of family Leguminosae—sub-family—Caesalpinioideae, is a native of tropical Africa but has been grown in India since prehistoric time. The tree is well adopted to semi-arid as well as to high rainfall condition and that is why it is now grown in Ceylon, India, Pakistan, East Indies, West Indies, Philippines, Java, Brazil, Maxico and Hawaii.

It is an evergreen tall plant, quite suitable for avenues and wind breaks. It is valued as firewood and makes excellent charcoal. Wood ash is used in tanning and dehairing of goat skin. Dye is extracted from leaves and it is a good dye for silk and woollen clothes. Beside several medicinal uses its fruits are good source of tartaric acid, sugar, alcohol, pectin and vitamins. Dried pulp is exported to Europe for preparation of chutney and sauces. Its seeds are good source of pectin and oil which is used in varnish of wood.

Blossom bud differentiation, pollination and fruit development has been extensively studied in most of the temperate and some of the tropical and subtropical fruits but tamarind has remained a neglected fruit so far. So the present studies have been made to collect information on various aspects of blossom bud differentiation and floral biology and fruit development under Kanpur (U.P.) conditions.

MATERIAL AND METHODS

The study was carried out in 1962-63 on the tamarind trees grown in the garden of the Govt. Agricultural College, Kanpur. These trees were about 50 years old and in full bearing.

The trees were divided in four different directions and observations were made under different heads on sampled branches.

For blossom bud differentiation 200 buds were tagged and samples were taken at weekly intervals from last week of March to middle of June to ascertain the time of differentiation. Twelve buds were taken every time. Buds were killed and fixed in F.A.A. Material after 10 minutes exhaustion, was dehydrated in Tert. Butyl alcohol after Johansen's method (1940). Longitudinal sections of 10-12μ in thickness were cut. They were stained in Delafields haematoxylin.

Observations on anthesis were recorded continuously for 5 days. The opened flowers were counted and recorded at hourly intervals and were removed after the observations to avoid recounting. The dehiscence of anthers was also observed at an hourly interval. Pollen size and shape were studied in methyl green glycerine jelly preparation. Artificial germination of pollen grains was tried in different concentrations of sucrose-agar medium (viz. 1, 2, 4, 6, 8, 10, 12, 15, per cent sucrose with 1·5% agar) at room temperature.

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Receptivity of stigma was studied both by visual observation and actual pollination method. In first method stigmas were observed with the help of hand lens (x 10) and only plump and shiny stigma having stickyness was considered receptive, whereas dried brownish stigma was taken as non-receptive. In second method previously emasculated flowers were cross-pollinated at different stigmatic age and were studied after 6 hours of pollination. Stigmas on which pollen grains had germinated were taken to be receptive.

To determine the mode of pollination four treatments viz. self-pollination, hand self-pollination, cross pollination, by hand and open pollination were compared. Fixed numbers of flowers were selected for each treatment and fruit set was recorded in all the cases one week after pollination.

RESULTS

Time of blossom bud differentiation—The broadening and flattening of apical meristem with two lateral protuberances one on either side of it, was taken as criterion for the blossom bud differentiation as suggested by Randhawa and Dinsa (1947) in citrus and Bajpai and Shukla (1963) in Loquat.

TABLE 1

Showing the number of differentiated buds at weekly intervals

S. No.	Date of collection	No. of buds differentiated	No. of buds collected	Max. mean temp. of the week in °C.
1.	25-3-62	12	...	33·5
2.	1-4-62	,,	...	35·1
3.	8-4-62	,,	...	37·0
4.	15-4-62	,,	...	37·7
5.	22-4-62	,,	...	37·0
6.	29-4-62	,,	...	37·5
7.	6-5-62	,,	2	38·0
8.	13-5-62	,,	3	38·8
9.	20-5-62	,,	6	40·7
10.	27-5-62	,,	9	43·7
11.	3-6-62	,,	11	42·9
12.	10-6-62	,,	12	43·3
13.	17-6-62	,,	12	39·7

No collections were made after 17.6.62.

The above table reveals that blossom bud differentiation started in first week of May i.e., on 6.5.62 when differentiation was observed only in 2 buds out of 12 buds. Number of differentiated buds continuously increased till 17.6.62 when all the buds, which were collected, differentiated. It also indicates that differentiation in Imli is a continuous process and it lasted for 24 days.

Organogeny of flower—Prior to differentiation of floral parts, vegetative bud was dome-shaped, with uniform curve and was surrounded by a number of scales. As soon as broadening of crown was observed, a small protrusion appeared on one side of the crown which formed outer bract (photomicrograph No. 1). Later on two protuberances appeared which formed inner bracts (Photomicrograph No. 2). Following the appearance of these bracts two other side primordia appeared on either side of the crown which showed rapid elevation giving an inverted bowl-shaped structure to the crown (Photomicrograph No. 3). These were the sepal primordia. On either side of these structures two small primordia of petals appeared followed by primordia of stamens and carpel (Photomicrograph No. 4). Thus the floral parts appeared in acropetal succession.

Flowering habit—Flowers appeared on young shoots of current season growth as well as on old wood. The inflorescence was 10-15 flowered lax, raceme which appeared terminally on short lateral branchlets. Basal buds matured first forming a succession of development for the rest of buds from base to apex (Photo No. 5). Flowers were hermaphrodite, nearly 1" in diameter. Though as many as 100 flowers appeared on each inflorescence but at a time not more than 15 flowers were observed due to shedding of old flowers. General trend about inflorescence is given in table 2.

TABLE 2

Studies of inflorescence based on average of 40 inflorescences.

	Length (cm.)	Breadth at centre (cm.)	Flowers/inflorescence
Max.	40·0	8·0	133
Average	15·7	5·3	48
Mini.	5·5	2·9	6

From the above table it is clear that there is a wide variation between maximum and minimum length and breadth of inflorescence and also in number of flowers per inflorescence.

Flowers began to appear from middle of May and continued till the end of September. A few flowers were also observed in December.

Bud development and anthesis—In the initial stage, flower buds were very small and were covered with pinkish or yellowish green bract which gave a beak-shaped appearance to the apex of the bud. After 4 or 5 days the outer bracts loosened and stamens and stigmas were distinctly visible although they were not fully developed. At this time the anthers were full of milky yellow juice. After 2-3 days outer bracts dropped off leaving two yellowish pink bracts. After another 2-4 days this second whorl of bracts dropped leaving 3rd whorl of bracts in the bended position. After some time these bracts also dropped off and bud showed slight swelling below the apex, probably due to pressure exerted by the developing androecium. After one or two days a slit was formed and fully developed gynoecium peeped out but androecium was still growing. After some time flower opened fully. The whole process was completed in 13-16 days. During the present studies the following abnormalities were observed:—

1. 4 or 5 petals per flower in place of 3.
2. 2 to 4 stamens in place of 3.
3. Flower with one staminode and two normal stamens.
4. Two anthers on one filament.

Forty to fifty flowers per day were observed daily at hourly intervals for anthesis. The effect of temperature and humidity was also observed. Anthesis was completed within 7 to 8 hours but sometimes it took as much as 32 hours. The percentage of flowers opened, together with metereological data are presented in table 3.

TABLE 3

Anthesis in Tamarind

Date of observation	Percentage of flowers opened at						No. of buds observed	Temp.		R. H. %
	3·30 a.m.	4·30 a.m.	5·30 a.m.	6·30 a.m.	7·30 a.m.	8·30 a.m.		Max.	Min.	
19-5-62	0	16·00	60·0	24·0	...	...	50	43·8	24·4	40
20-5-62	0	14·00	56·0	26·0	4	...	50	42·1	21·9	57
21-5-62	0	10·00	42·0	38·0	10	...	50	41·6	27·4	65
22-5-62	0	17·50	58·0	22·5	2	...	40	43·7	25·4	53
23-5-62	0	15·00	62·5	17·5	5	...	40	43·3	29·7	44

The above table indicates that the maximum anthesis occurred between 4·30 and 5·30 a.m. It is also apparent that high temperature with low relative humidity increased the number of flowers which opened in early hours of day.

All the anthers did not dehisce at one time. Anthers took 6-8 minutes for completing their dehiscence and under normal conditions all anthers dehisced within an hour. Anthers dehisced longitudinally exposing shiny pale coloured mass of pollen. Maximum dehiscence occurred between 8·30 to 9·30 a.m. in all flowers. High temperature favoured early dehiscence. 28·5-29·8°C temperature associated with 52-60 per cent relative humidity gave highest percentage of normal dehiscence while at higher temperature and low humidity anthers dried without dehiscence.

Pollen grains, mounted in methyl green gelly were roundish to oval in shape having 2-4 germpores, 3 being common. Exine and intine were clear. The range of pollen grain size is presented in table 4.

TABLE 4

Showing size of pollen grains

Particulars	Length in μ	Breadth in μ
Maximum	43·2	40·0
Minimum	35·2	32·0
Average of 400 pollen grains	40·0	35·2

The viability as determined by acetocarmine test was only 84 per cent in the tamarind pollen grains. In artificial germination test pollen grains started germination after 5 hours of planting and 8% sucrose with 1·5% Agar gave maximum (32·8%) germination which clearly indicates the poor germinating capacity in artificial medium. However, germination tests on stigma resulted in 100% germination of pollen (Photomicrograph No. 6).

Receptivity of stigma—By visual observation it was concluded that stigmas were receptive only one day before anthesis and remained in this condition upto 2 days after anthesis. More accurate results were obtained by controlled pollination of emasculated flowers at different stigmatic age. Results are summarised in table 5.

TABLE 5

Showing the receptivity of stigma

Age of stigma in relation to anthesis	No. of stigmas studied	Stigmas with germinated pollen	Percentage of receptivity of stigma
3 days before	20	...	...
2 days before	20	8	40
1 day before	20	10	80
On the day of anthesis	20	20	100
1 day after	20	20	100
2 days after	20	14	70
3 days after	20	...	...

From the above studies it is clear that highest receptivity of stigma was on the day of anthesis and after a day of anthesis. After 3 days of anthesis the receptivity was nil.

Pollination studies—There are no established clonal varieties so in the present studies self-pollination refers to transfer of pollen from one flower to stigma of another flower of same plant while cross pollination means the transference of pollen from one plant to the stigma of flower of another plant. To determine the mode of pollination, the following treatments were compared:—

1. *Self pollination*—Fully developed and unopened flower buds were bagged before anthesis.
2. *Hand self pollination*—Flowers were bagged before anthesis and then pollinated by hand from same plant.
3. *Hand cross pollination*—Flowers were emasculated and pollinated by hand with the pollen of other plants.
4. *Open pollination*—Flowers were marked with India Ink to record fruit set under normal conditions.

Fruit set was recorded after one week and the results are given in table 6.

TABLE 6

Showing relative value of various modes of pollination

S.No	Mode of pollination	No. of flowers studied	No. of fruits set	Percentage of fruit set
1.	Self pollination	180	16	8·90
2.	Hand self pollination	200	164	84·00
3.	Hand cross pollination	200	171	85·50
4.	Open or natural pollination	288	82	24·00

The above table reveals that higher percentage of fruit set was obtained by artificial pollination. In case of natural pollination sometimes no trace of pollen grains was obtained on several stigmas and this may be responsible for low fruit set.

FRUIT SET STUDIES

For fruit set studies 20 inflorescences were tagged and total number of flowers on them were counted. The initial and final fruit set were recorded. Results are summarised in table 7.

TABLE 7

Showing the percentage of initial and final fruit set

No. of flowers under study	No. of flowers dropped	% of flowers dropped	No. of fruits set	Percentage of fruit set	
				Initial	Final
8892	8777	98·7	115	1·30	0·844

The foregoing table clearly indicates that the percentage of initial fruit set was 1·30% and out of which only 0·844% could reach maturity.

DISCUSSION

The blossom bud differentiation in tamarind began with the resumption of vegetative growth just after leaf fall but there was no total shedding of leaves. Similar phenomenon has also been observed by Bajpai and Maurya (1963) in Kaitha. Floral organs developed in acropetal order as reported in other fruit crops.

The flowers were borne on the young current season's growth as well as on old wood. The inflorescence was 10-15 flowered raceme and it developed terminally on short lateral branchlets as reported by Dasture (1956).

Maximum anthesis took place between 4·30-5·30 a.m. (Table 3). A higher temperature and low humidity favoured early anthesis of flowers. Randhawa and Nair (1960) have also recorded similar results in plum under Delhi conditions. However, Randhawa and Damodaran (1961) did not observe any correlation between atmospheric temperature, humidity and rate of anthesis in case of mango. Maximum anther dehiscence was observed between 8·30 and 9·30 a.m. High temperature with low humidity increased the rate of dehiscence and this is in agreement with the results of Randhawa and Nair (1960) in mango. At the same time intense heat and very low humidity desiccated the anthers with the result that they did not dehisce. Stigma became receptive two days before anthesis and remained so upto 3rd day of anthesis. But maximum receptivity of stigma was recorded on the day of anthesis. Similarly Randhawa and Nair (1960) observed maximum percentage of pollen germination on the stigma on the day of anthesis.

Pollination studies showed greater percentage of success with hand or artificial pollination (upto 85·5%) as compared with natural or open pollination (23%). This was due to the fact that flowers of tamarind are protogynous i.e., stigma matures first than anthers. So it does not receive enough pollen while in hand pollination ample pollen was placed on stigma which resulted in greater fruit set. Randhawa and Nair (1960) also reported the maximum percentage of fruit set by hand pollination among all other modes of pollination. In case of natural or open pollination no trace of pollen grains was observed on several stigmas under study which clearly confirms that less success in this case was due to nonavailability of pollen grains at proper time.

Only 1·30% flowers set fruits and only 0·844% reached maturity. Thus fruit drop is a serious problem. This drop may be due to lack of fertilization or ovule or embryo abortion at different stages of development. In mango Hartless (1914), Young (1942) also suggested that the shedding of hermophrodite flowers and of immature fruits was mainly due to inadequate pollination and zygote abortion. It may also be due to competition among fruits for something, the tree supplies in limited quantities (Chandler, 1957).

SUMMARY

The present investigation was conducted to study bearing habits of Imli (*Tamarindus indica* Linn.) The findings of the study are given below:—

1. Buds started to differentiate from 6.5.62 with the resumption of vegetative growth just after leaf fall. Differentiation was complete by 10.6.62.

2. Floral parts appeared in acropetal succession.

3. Inflorescence was a raceme borne terminally on current season's growth as well as on old wood.

4. Blooming season lasted from 3rd week of May to the end of September under Kanpur conditions.

5. Ten distinct stages of bud development were recorded and flower buds reached anthesis stage in about 13-16 days after their appearance.

6. Maximum dehiscence of anthers was recorded between 8·30 and 9·30 a.m.

7. Pollen grains mounted in methyl green glycerine jelly were roundish to oval in shape having 2-4 germpores.

8. Best germination of pollen grains was obtained in 8% sucrose with 1·5% Agar.

9. Stigmas became receptive two days before anthesis and remained so upto the third day of anthesis.

10. The initial fruit set was 1·30% but only 0·844% flowers reached final maturity.

REFERENCES

1. Bajpai, P. N. & Maurya, A. N. 1963. Blossom bud differentiation in Kaitha (*Limonia acidissima*). *Agra Unvi. J. Res.* (*Sci.*) **XII** (III) : 97-104.
2. Bajpai, P. N. & Shukla, R. K. 1962. Blossom bud differentiation in Loquat (*Eriobotrya japonica* L.) *Sc. & Cult.* **28** : 478-79.
3. Chandler, W. H. 1957. Deciduous orchards. 3rd Ed. Lee and Febiger. Philadelphia, p. 84.
4. Dasture, J. F. 1956. *Tamarindus indica* Linn. *Useful plants of India and Pakistan* : 201-202.
5. Hartless, A. C. 1914. Mango crops and some factors influencing them. *Agri. J. India*. **9** : 144-50.
6. Johansen, A. D. 1940. Plant microtechnique. MacGraw Hill Publ. New York.
7. Randhawa, G. S. & Dinsa, H. S. 1947. Relation of growth to fruiting in citrus. *Proc. Amer. Soc. Hort. Sci.*, **50** : 165-171.
8. Randhawa, G. S. & Nair, P. K. 1960. Study on floral biology of plum grown under subtropical conditions. *Ind. J. Hort.*, **17** (2) : 83-101.
9. Randhawa, G. S. & Damodaran, V. K. 1961. Studies on floral biology and sex ratio in mango (*Mangifera indica* L.) II. Flowering habit, flowering season, panicle development and sex ratio. *Indian J. Hort.*, **18** : 36-45.
10. Young, T. W. 1942. Investigations on the unfruitfulness of Haden mango in Florida. *Proc. Fla. Sta. Hort. Soc.*, **55** : 106-10.

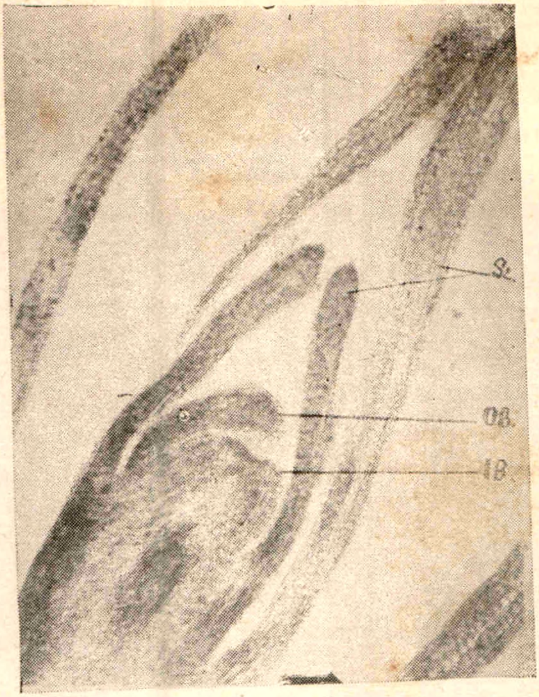

Fig. 1 L.S. of bud showing primordia of outer and inner bracts 10X×10X.
SC—Scales. OB—Primordium of outer bract. IB—Primordium of inner bract.

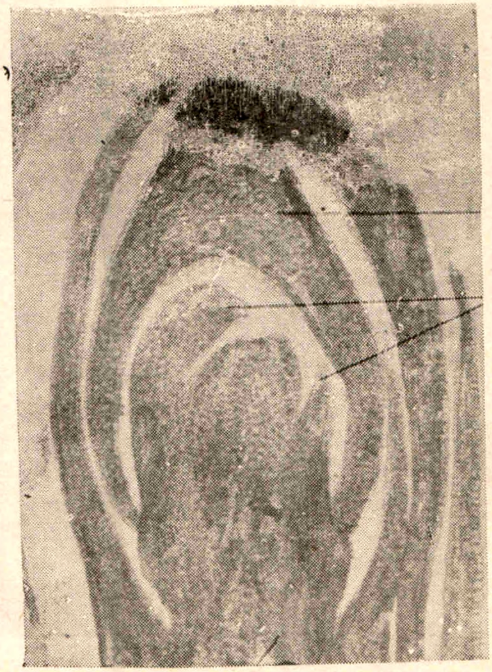

Fig. 2. L.S. of bud showing flattening and broadening of crown.
(Predifferentiation stage)
OB—Primordium of outer bract. IB—Primordia of inner bract.

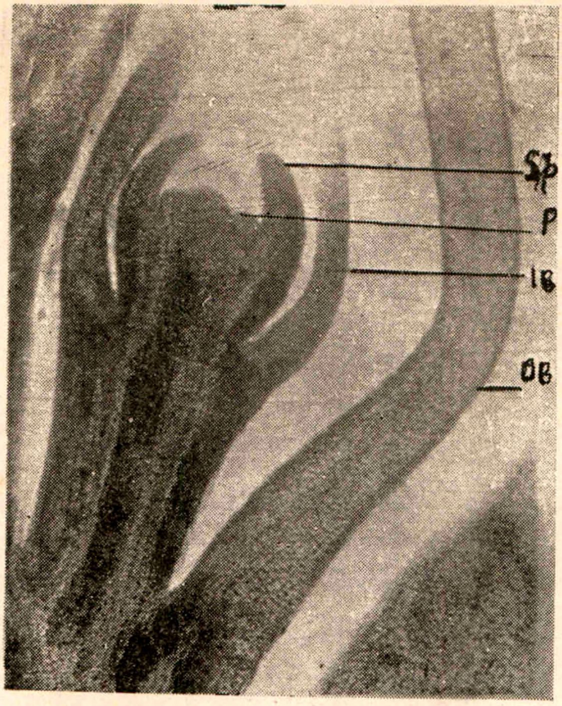

Fig. 3. L.S. of bud showing developed sepal and petal primordia 10X×10X, Sp—Sepal primodia. P—Petal primordia. IB—Inner bract. OB—Outer bract.

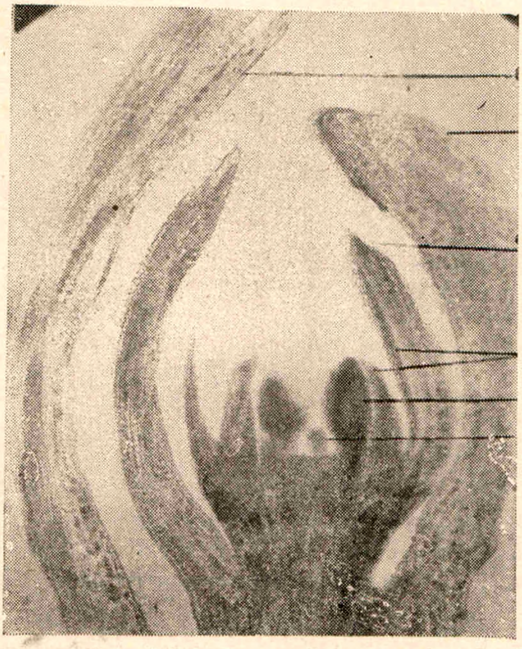

Fig. 4. L.S. of the well developed flower bud 10X×10X. OB—Outer bract. IB—Inner dract. Sp—Sepal. P—Petal. St—Stamen. Pi—Pistil

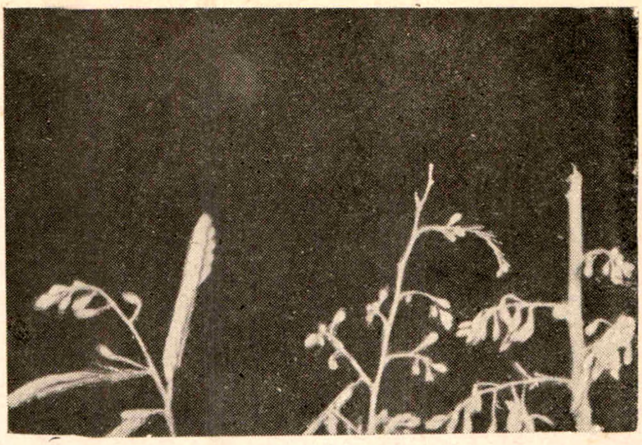

Fig. 5. Flowering habit of Tamarind.
A—Inflorescence of current shoot growth. B—Inflorescence on one year old wood.
C—Inflorescence directly on several years old wood.

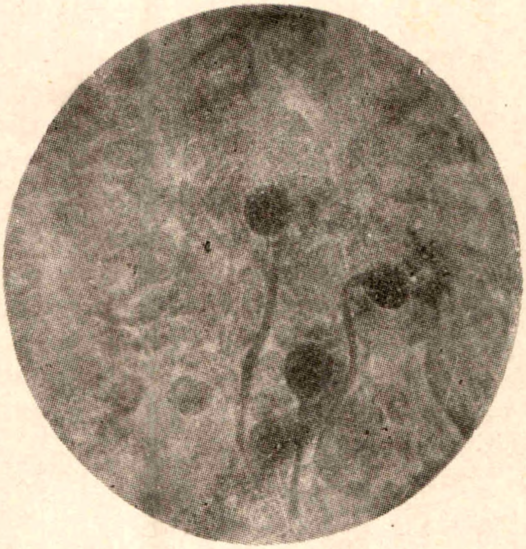

Fig. 6. Showing pollen germination on stigmatic surface.

STUDIES IN PECTIC ENZYMES OF PARASITIC FUNGI.
XI. INHIBITORY EFFECT OF SOME FUNGICIDES ON THE PRODUCTION AND ACTIVITY OF PECTIC ENZYMES OF *ALTERNARIA TENUIS*

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A number of fungicides, antibiotics and other chemicals have been reported to reduce or check the production and activity of pectic enzymes of pathogenic fungi[3,4,9,11]. Though Husain and Rich[7] did not find any significant effect of fungicides on polygalacturonase (PG) yet Grover[5] found several fungicides having inhibitory effect on protopectinase enzyme (PP). Recently Prasad and Gupta[10] examined the effect of thirty fungicides on the production and activity of PP and PG enzymes of *Rhizoctonia solani* and recorded that all the fungicides adversely affected the growth of the fungus but only those which had copper in them inhibited the activity of PP and PG enzymes.

The present work was undertaken to study the effect of several fungicides on the growth of *Alternaria tenuis* Ness. ex Pers. and on the production and activity of its PP and PG enzymes.

Materials and Methods

Active PP and PG was obtained by growing *A. tenuis* in flat bottles on 15 ml. synthetic liquid culture medium containing 1% pectin, 0·2% asparagine, 0·3% potassium dihydrogen phosphate and 0·05% magnesium sulphate. The medium was sterilized, inoculated with the spores of the fungus from a week-old culture and incubated at 25°C. for four days. The mycelium was removed after the incubation, the filtrate centrifuged and the supernatant used as the enzyme preparation.

PP was assayed by potato disc method and its activity in per cent was calculated by the formula 1000/MT, where MT represented the time in minutes taken by 0·5 mm. thick potato disc to macerate.

PG was assayed by the viscometric method using sodium polypectate solution. This enzyme was assumed to be 100 per cent active when its 1 ml. reduced in one minute the viscosity of 0·5 ml. of 1 per cent solution of sodium polypectate to that of distilled water.

The inhibitory effect of chemicals on the production of the enzymes and the growth of the fungus was studied by adding before sterilization various fungicides in the culture medium in 0·1 per cent concentration. After the incubation period the mycelium of the fungus was collected on filter paper, washed and dried at 70°C. and then weighed while the filtrate was assayed for PP and PG enzymes.

The inhibitory effect of the fungicides was assayed by adding 1 ml. of 1 per cent fungicide solution to 9 ml. of active enzyme preparation at 3·5 pH so as to have 0·1 per cent final concentration of the fungicide in the solution. The final solution of fungicide and enzyme was allowed to react for 1 hour and then it was assayed for PP and PG enzymes.

All the tests of PP and PG enzymes were conducted at 30°C. and 5·0 pH. Distilled water was used in place of fungicides for control experiments. The experiments were run in triplicate and repeated twice to record the average and mean values.

OBSERVATIONS AND DISCUSSIONS

When fungicides were added to the culture medium before growing the fungus over it, 28 out of the 30 fungicides completely checked the growth of the fungus and thus the production of PP and PG enzymes was also checked (table 1). The remaining two fungicides, Fungimar and Tillex, did not check completely the growth of the fungus but only reduced it. The production of pectic enzymes was also reduced in the two cases.

However, when the effect of fungicides was studied on the active preparation of PP and PG enzymes, it became clear that the following thirteen fungicides had no effect on the activity of PP and PG enzymes: Arasan, Agrosan 5W, Agrosan G.N., Ceresan, Ceresan dry, Ceresan wet, N.I. Ceresan, Dithane Z-78, Lunasan, Spergon, Thiram, Tritisan and Ziram. The following seven fungicides affected the activity of PG enzyme only to little extent: 2% Ceresan, Dithane S-31, Dithane M-22, Fusariol, Harvesan, Phygon and Tillex. All the remaining 10 fungicides inhibited the PP enzyme out of which the following 8 made the PP completely inactive: Blitox, Coppesan W.P., Coprantal, Cupper sandoz, Cupramar, Fungimar, Fytolan and Shell copper. The remaining two, Flit 406 and Thiovit inactivated, along with PP, PG also to some extent. However, it was uncertain whether Blitox, Coppesan W.P., Coprantal, Cupper sandoz, Cupramar, Fytolan and Shell copper also inactivated PG as the addition of these fungicides coagulated the sodium polypectate solution. In no case complete inactivation of PG enzyme was recorded.

From the results it is obvious that all the eight fungicides, which contained copper in them, not only checked the growth of the fungus but also completely inhibited PP enzyme. These fungicides also proved to some extent to be inhibitory to PG. On the other hand those fungicides which had mercury, manganese, sulphur and zinc in them had only fungistatic value and no or very little value as pectic enzyme inhibitors.

TABLE I

Effect of fungicides on the production and activity of pectic enzymes

Fungicide	Active ingredient	Effect on secretion			Effect on activity	
		Dry Wt. in mgm.	% PP	% PG	% PP	% PG
Control	Distilled water	50	83	95	83	95
Arasan	Bis dimethylthiocarbomyl disulphide	...	...	...	83	95
Agrosan 5W	Organically combined mercury	...	...	...	83	95
Agrosan GN	Tolymercury acetate	...	...	...	83	95
Blitox	Copper oxychloride	...	...	...	00	Cg
Coppesan W.P.	Copper oxychloride	...	...	...	00	Cg
Coprantal	Copper oxychloride	...	...	...	00	Cg
Cu-sandoz	Cuprous oxide	...	...	...	00	Cg
Cupramar	Cuprous oxide	...	...	...	00	Cg
Ceresan	Phenyl-mercury acetate	...	...	...	83	95
2% ceresan	Ethyl mercury chloride	...	...	...	83	91
Ceresan dry	Phenyl mercury chloride	...	...	...	83	95
Ceresan wet	Methyl ethyl mercury-chloride	...	...	...	83	95
N.I. ceresan	Ethylmercury phosphate	...	...	...	83	95
Dithane S-31	Sulphur ethylene bis-dithiocarbomate	...	...	...	83	91
Dithane M-22	Manganese ethylene bis-dithiocarbomate	...	...	...	83	85
Dithane Z-78	Zinc ethylene bis-dithiocarbomate	...	...	...	83	95
Fungimar	Cuprous oxide	38	03	50	00	46
Flit 406	n-(trichloromethylmercapto)-4-cyclohexene-1,2-dicarboximide	...	...	...	03	70
Fytolan	Copper oxychloride	...	...	...	00	Cg
Fusariol	Ethyl mercury cyanide	...	...	...	83	86
Harvesan	Organically combined mercury	...	...	...	83	86

TABLE 1 (*Contd.*)

Fungicide	Active ingredient	Effect on secretion			Effect on activity	
		Dry Wt. in mgm	% PP	% PG	% PP	% PG
Lunasan	1-(ethyl mercury)-2-thiourea	...	...	...	83	95
Phygon	2,3 dichloro-1-4-naphthoquinone	...	...	...	83	93
Shell copper	Copper oxychloride	...	...	...	00	Cg
Spergon	Tetrachloro-p-benzoquinone	...	...	...	83	95
Thiovit	25–28% polysulphides	...	...	...	40	86
Thiram	bis-dimethyl thiocarbamoyl disulphide	...	...	...	83	95
Tillex	Ethylmercury chloride	40	17	67	83	93
Tritisan	Pentachloronitro benzene	...	...	...	83	95
Ziram	Zinc–dimethyl-dithiocarbamate	...	...	...	83	95

...= No growth and no production of enzymes.
Cg= Solutions coagulated.

There appears to be no agreement between the observations of different workers regarding the inhibitory effect of various chemicals on pectic enzymes of different fungi. Some workers did not find compounds of heavy metals to be inhibitory to pectic enzymes[6],[8] while others recorded the inhibitory action of calcium[1],[2]. Husain and Rich[7] found only 5 fungicides out of 12 to be moderately inhibitory to PG enzyme of *Cladosporium cucumerinum*. Two of the fungicides which were found to be inhibitory by Husain and Rich[7] were similar to Phygon and Ziram used in this work. However, the present authors recorded no inhibitory effect of these fungicides on the PP and PG of *Alternaria tenuis*. These fungicides had no inhibitory effect on the activity of PP and PG of *Rhizoctonia solani* also[10].

The view of Husain and Dimond[6] that a therapeutant may not necessarily be a pectic enzyme inhibitor is fully endorced by the results presented in this work as only 17 fungicides out of 30 show inhibitory effect on PG. From the results presented in this work it also appears that an inhibitor does not equally affect different pectic enzymes as only 10 fungicides affect macerating enzyme (PP) against 17 affecting polygalacturonase (PG).

SUMMARY

Effect of 30 fungicides on the production and activity of protopectinase and polygalacturonase enzymes and on the growth of *Alternaria tenuis* was studied. It was recorded that all the fungicides which had copper in them

checked the growth of the pathogen and also inhibited the activity of pectic enzymes. The other fungicides, which contained mercury, zinc, sulphur and manganese, checked the growth of the fungus but had no or little effect on the activity of pectic enzymes. Fungicides containing copper in them fully inactivated the macerating enzyme (PP) but none could completely inactivate the polygalacturonase (PG) enzyme.

ACKNOWLEDGEMENTS

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REFERENCES

1. Bateman, D.F. 1964. *Phytopathol.*, **54** : 438.
2. Corden, M. E 1965. *Phytopathol.*, **55** : 222.
3. Grossman, F. 1962. *Phytopath. Z.*, **44** : 361.
4. Grover, R. K. 1963. *Curr. Sci.*, **32** : 398.
5. Grover, R. K. 1964. *Phytopathol.*, **54** : 130.
6. Husain, A. & Dimond, A. E. 1958. *Proc. National Acad. Sci., U. S.*, **44** : 594.
7. Husain, A. & Rich, S. 1958. *Phytopathology*, **48** : 316.
8. Miller, R. L. 1965. *Phytopathol.*, **55** : 130.
9. Prasad, V. 1967. *Proc. Indian Acad. Sci.*, **65 B** : 119.
10. Prasad, V. & Gupta, S.C. 1967. *36th Annual Session, National Acad. Sci., India*, Abst. B. 18.
11. Wood, R. K. S. 1959. *Plant Pathology Problems and Progress*, Univ. of Wis., 100.

STUDIES ON THE ANTIFUNGAL PROPERTIES OF THE EXUDATES OF FUNGI I. FUNGAL EXUDATES INHIBITING UREDOSPORE GERMINATION OF *PUCCINIA PENNISETI* ZIMM.

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Fungi are known to exude certain substance which differ in their reaction to litmus - paper and their chemical composition (Wilson, 1948). Exuding drops were collected from the surface of young sporangiophores of *Mucor mucedo* by Brefeld (1872) and *Pilobolus crystallinus* and *P. longipes* by Wilson (1881) and Lepeschkin (1906) respectively. Thom (1930) also reported the presence of exudation drops on the colonies of penicillia. Fungal spores are also known for their ability to secrete certain substance (Backus, 1939) and it is possible, therefore, that spores lying on the surface of host leaves may produce exudates. If these substances get dissolved in water films of dew, they are likely to exert some influence on the germination of the spores of parasitic forms and eventually infection of the host. In the present communication four species of *Aspergillus*, two of *Penicillium* and one each of *Rhizopus* and *Fusarium* were noted for their quality to exude glistening drops on Czapek's medium. The exudates of the above fungi were collected and tested for their efficacy on the germination of uredospores on *Puccinia penniseti* Zimm. causing the rust disease of *bajra* (*Pennisetum typhoides* Stapf and Hubb.).

The exudates of all the fungi under study were collected with the help of self-filling capillary tubes and diluted with Pyrex double-distilled water in equal volume. The individual effect of the exudates was studied on the germination of uredospores of *Puccinia penniseti*, following hanging drop method. Mature uredospores were collected by dusting the leaves of diseased plants, growing in a glasshouse. Uredospores were germinated in the presence of the exudates at 18°C (±1). A control in double-distilled water was kept side by side. Germination counts of uredospores were recorded after 24 hours of incubation

Percentage uredospore germination in the exudates of various fungi has been summarised in the table.

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TABLE

Effect of fungal exudates on the germination of uredospores of Puccinia penniseti Zimm.

(Mean of 50 observations)

Fungus	Colour of the exudate	% germination	% inhibition
Rhizopus arrhizus Fischer	Yellowish brown	100·00	00·00
Aspergillus sydowi Thom & Church	orange red	90·28	09·72
A. terreus Thom	bright yellow	50·22	49·78
A. japonicus Saito	dull brown	03·29	96·71
A. quercinus Thom & Church	light yellow	05·10	94·90
Penicillium oxalicum Currie & Thom	dull red	77·93	22·07
P. citrinum Thom	bright yellow	100·00	00·00
Fusarium moniliforme Scheldon	colourless	100·00	00·00
Control		100·00	00·00

The above table reveals that out of eight fungal exudates those from *Rhizopus arrhizus*, *Penicillium citrinum* and *Fusarium moniliforme* have no effect on the germination of uredospores of *Puccinia penniseti* (100% germination as also in control), whereas the remaining five exudates affect the germination to a varying degree. Based on the inhibition percentage their order of efficacy in inhibiting uredospore germination of *Puccinia penniseti* is:—*Aspergillus japonicus* (96·71%)>*A. quercinus* (94·90%)>*A. terreus* (49·78%)>*Penicillium oxalicum* (22·07%)>*Aspergillus sydowi* (9·72%). It is also noteworthy that the various exudates are of different colours.

Several fungi have been reported to produce 'drops' in nature as well as on synthetic cultural media. Wilson (1948) compared this exudation with that which occurs in green plants (guttation). According to him fungi start exuding in morning when the temperature is rising and stop near about mid day, whereas in vascular plants it begins when the temperature is falling and continues till the morning. Thom (1930) described such exudates from Penicillia as 'drops' resultant of the accumulation of the transpired fluid. Colour and other properties of the exudates were also shown by him to differ from species to species.

The production of antibiotics has been demonstrated in a large number of fungi (Florey *et al.*, 1949; and Dymovych, 1960). These toxic substances of fungal origin may be inhibitory to the germination of their own spores (Allen, 1955; Forsyth, 1955; Kapooria, 1964) or they may retard the germination and growth of some other fungi (Florey *et al.*, 1949).

The analysis of the table reveals that the exudates of *Rhizopus arrhizus*, *Penicillium citrinum* and *Fusarium moniliforme* have no effect on the germination of uredospores of *Puccinia penniseti* Zimm. The exudates of the remaining five fungi show a varying effect. *Aspergillus sydowi* is the least effective with 9·72%, *A terreus* showed 49·78% inhibition, *A. japonicus* had the maximum inhibition capacity (96·71%), *A. quercinus* with 94·90% inhibition was the second most effective and *Penicillium oxalicum* inhibited the germination of uredospores by 22·07%.

ACKNOWLEDGEMENT

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REFERENCES

1. Allen, P. J. 1955. The role of self-inhibitor in the germination of rust uredospores. *Phytopathology*, **45**; 259 266.
2.* Backus, M. P. 1939. The mechanics of conidia fertilization in *Neurospora sitophila*. *Bull Torr. Bot. Club*, **66** : 63-76.
3.* Brefeld, O. 1872. Untersuchungen uber Pilze. Heft I, Leipzig, : 12.
4.* Dymovych, V. O 1960. The action of volatile antibiotics from different cultures of *Trichoderma* species on phytopathogenic bacteria and fungi *Jour. Microbiol*, Kiew, **22** : 32-38.
5. Florey, H. W. E.; Chain, N. G.; Heatley, M. A.; Jennings, A. G. Sanders, E. P. Abraham & M. E. Florey 1949. Antibiotics, a survey of penicillin, streptomycin and other antimicrobial substances from fungi and plants. 2 Vols., *Oxford Univ. Press* New York, 273-355.
6. Forsyth, F. R. 1955. The nature of the inhibiting substance emitted by germinating uredospores of *Puccinia graminis tritici*. *Canadian Jour. Bot.*, **33** : 363-373.
7. Kapooria, R. G. 1964. Studies in the epidemiology, cytology and chemotherapy of *bajra* and lentil rusts, Ph. D. Thesis, Agra University.
8.* Lepeschkin, W. W. 1906. Zur kenninis des Mechanismus der aktiven wasseraussscheidung der Pflangen, *Beihefte. Bot. Zentalbatt* : 409-452.
9. Thom, C. 1930. The Penicillia. Williams and Wilkins Co., Baltimore.
10. Wilson, W. P. 1881. The cause of excretion of water on the surface of nectaries. *Unters a. d. Bot. In t. zu Tubingen* : 15.
11. Wilson, J. K. 1948. An examination of the exudate and juice of certain fungi found in their native environment. *Mycologia*, **40** : 605–613.

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* Original not seen.

EFFECT OF PLANT POPULATION AND FERTILITY LEVELS ON POD DEVELOPMENT IN SOYBEAN

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Introduction

Soybean is one of the most important oilseeds and pulse crop throughout the world, though it is not yet commonly grown in India. It is now being realised that soybean may be a good source of protein in the diet of the millions of people of our country since its protein content is the highest amongst grains and pulses. The information on various aspects of growing soybean is very meagre in the country. Initiation of flowering, fruiting and pod development, which ultimately affect the magnitude of yield are influenced, among other things, by number of plants per unit area and the fertility status of soil. Lehman and Lambert (1960) found that the number of seeds and pods produced per plant, were less in 20 inches (50 cm.) than in 40 inches (100 cm.) rows, but the total yield was in reverse order. The number of flowers per plant decreased with closer spacing in an experiment conducted at Ontario, Canada (Anonymous, 1962). Burnside and Colville (1964) worked on soybean at Lincoln, Nebraska (U.S.A.) and reported that the number of pods per plant increased steadily with increased row spacings. Valaunathan (1947) found at Pusa that application of appropriate doses of phosphorus gave an increase of 40 ot 44 per cent in the number of pods over control. Patro (1949) at I. A. R. I. New Delhi, observed that phosphorus had a marked effect in increasing the number of pods. Lathwell and Evans (1951) found that a high level of nitrogen was necessary in the soil during bloom period for maximum yield in soybean. Khot (1958) reported that the application of phosphorus increased the flower pod ratio.

Materials and Methods

The experiment was conducted at the Students' Instructional Farm, Government Agricultural College, Kanpur (U. P.), during *Kharif*, 1965. The design of the experiment was split plot in Randomised Complete Block with 3 replications. Following were the treatments :—

Spacing—25, 50 and 75 cm. between rows and 10 cm. between plants i. e., 4,00,000; 2,00,000 and 1,33,333 plants per hectare respectively.
Nitrogen—0 and 10 kg. of nitrogen per hectare.
Phosphorus—0, 20, 40, 60 and 80 kg. P_2O_5 per hectare.

Five plants were selected randomly from each plot. The number of flowers and pods per plant were counted. For the study of pod characters, 25 pods were picked from five randomly selected plants of each plot. The length and weight of the pods, number and weight of grains per pod and weight of 100 seeds were studied. The moisture percentage in the grains was determined with the help of Steinlite Electronic Moisture Tester.

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RESULTS

The results regarding the number of flowers and pods per plant, pod characters, test weight and moisture percentage in seeds are given in tables 1 to 3 and Figs. 1 and 2.

TABLE 1

Effect of spacing and fertility levels on pod development of soybean

(80 days after sowing)

Treatments	No. of flowers per plant	No. of pods per plant	Length of pod in cm.	Weight per pod in gm.	No. of grain per pod	Weight of grains per pod	Test weight (100 seed wt. in gm.)	Moisture percentage in seed
Spacing (cm.)								
25	54·2	76·7	3·31	0·35	2·52	0·22	7·83	10·24
50	75·3	96·7	3.40	0·44	2·58	0·29	7·83	9·59
75	78·0	103·2	3·58	0·52	2·66	0·33	7·82	9·51
Mean	69·16	92·20	3·43	0·43	2·58	0·28	7·82	9·78
'F' test	Sig.	Sig.	N.S.	Sig.	Sig.	Sig.	N.S.	N.S.
S.Em. ±	0·30	1·02	0·10	0·04	0·04	0·01	0·04	0·41
C.D. at 5% level	1·17	3·96	0·39	0·13	0·13	0·03	0·18	1·60
Nitrogen (kg/ha)								
0	66·8	92·1	3·41	0·44	2·59	0·26	7·82	9·84
10	71·6	92·7	3·45	0·43	2·58	0·32	7·84	9·94
Mean	69·2	92·40	3·43	0·43	2·58	0·29	7·83	9·89
'F' test	Sig.	N.S.	Sig.	N.S.	N.S.	Sig.	N.S.	N.S.
S.Em. ±	0·50	1·35	0·02	0·02	0·02	0·005	0·05	0·42
C.D. at 5% level	1·38	3·72	0·03	0·03	0·03	0·01	0·13	1·16
Phosphorus (kg/ha)								
0	67·8	75·7	3·21	0·30	2·45	0·20	7·62	10·01
20	70·5	90·7	3·37	0·43	2·58	0·28	7·80	10·10
40	69·4	95·8	3·42	0·45	2·57	0·28	7·88	9·55
60	67·9	99·2	3·57	0·48	2·65	0·34	7·91	9·60
80	70·4	102·2	3·57	0·50	2·67	0·33	7·92	9·70
Mean	69·20	78·72	3·42	0·43	2·58	0·28	7·82	9·79
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	N.S.
S.Em. ±	0·80	2·11	0·03	0·03	0·03	0·008	0·08	0·21
C.D. at 5% level	2·19	5·82	0·08	0·08	0·08	0·021	0·22	0·58

Results in the above table indicate that number of flowers and pods per plant were increased in a linear order when the spacing was increased from 25 cm. to 75 cm. This increase was observed from the early growth stages of the plants (Figure 1 and 2). Weight, number of grains and weight of grains per pod were also increased with increase in spacing i. e., with lower plant population. The length of the pod, 100 seed weight and seed moisture per cent were not markedly influenced by row spacing.

The nitrogen application significantly increased the number of flowers length of pods and weight of grains per pod, while in early stages, a significant increase in flowers and pods per plant was observed (Figs. 1 and 2). The weight and number of grains per pod, test weight and moisture percentage in seeds were not affected by nitrogen application.

It is clear from the table that number of flowers and pods per plant, length, weight, number of grains and weight of grains per pod were significantly increased with phosphorus application over control. Since the early stages of plant growth, increase in number of both flower and pods per plant with increase in doses of P_2O_5 was noted (Figs. 1 and 2). The response, in general, was a linear order increasing with increase of phosphorus. The moisture percentage in seeds was not influenced by application of P_2O_5 at the time of harvesting. The effect of significant inter-action SXP is given in table 2.

TABLE 2

Effect of S X P on number of flowers per plant

Number of flowers at 50 days stage

Number of pods at 65 days stage

Doses of P_2O_5 kg/ha	Spacing between rows (cm.)			Mean	'F' test	S. Em. ±	C.D. at 5% level
	25	50	75				
0	5·8	6·9	7·5	6·73	Sig.	0·81	2·23
	(16 0)	(27·9)	(22·0)	(21 93)	(Sig)	(0·16)	(0·43)
20	7·3	8·5	8·3	8·03			
	(18·1)	(24·7)	(24·5)	(22·43)			
40	7·9	7·1	7·0	7 33			
	(18·7)	(23·0)	(26·8)	(22·83)			
60	6·4	6·5	7·0	6·63			
	(20·5)	(41·7)	(30·8)	(31·0)			
80	6·8	7·4	8·6	7·60			
	(19·8)	(30·5)	(30·5)	(26·93)			

A perusal of the above data show that the number of both flowers and pods per plant were increased with the application of phosphorus with wider spacing i. e., lower plant population. The number of flowers were highest with 20 kg. P_2O_5 in 50 cm. with similar response in 75 cm. spacing with higher doses of P_2O_5. The number of pods were highest in 50 cm. spacing with 60 kg. P_2O_5 per hectare. The significant effect of interaction NXP was observed in moisture percentage of soybean seeds.

TABLE 3

Effect of N X P on Moisture percentage in seed

Nitrogen (kg/ha)	Doses of P_2O_5 (kg/ha)					Mean	'F' test	S. Em.	C.D. at 5% level
	0	20	40	60	80				
0	9·7	10·6	9·1	9·1	10·5	9·80	Sig.	±0·29	0·80
10	10·4	9·9	9·9	10·1	9·1	9·88			

The data given in the above table indicate that the phosphorus, when applied in conjunction with nitrogen, reduced the moisture content in seeds. The application of nitrogen increased the moisture percentage in seeds at the time of harvesting the crop.

DISCUSSION

An increase in the number of flowers and pods per plant was found as the spacing between rows was increased from 25 to 75 cm. The initiation of flowering in the plants was observed about 50 days after sowing and was completed after 15 days i. e., 65 days after sowing. The flower count at 80 days stage showed a decrease in number, since the pod formation, which commenced at 65 days stage was complete to the extent of more than 50 per cent at 80 days. The number of flowers and pods in higher plant populations were less due to the crowding of the plants and consequently reduced branching. As a result of this, the weight, number of grains and weight of grains per pod were also higher with low plant population. The work done by Lehman and Lambert (1960) and Burnside and Colville (1964) has also shown similar response. The weight of 100 seeds and moisture percentage in seeds at the time of harvesting were unaffected with the row spacing.

The increase in number of flowers with nitrogen application was more marked than in number of pods. It shows that more nitrogen is required for blooming, while it has no direct effect with pod formation (Lathwell and Evans, 1951). Length and number of grains per pod were increased with 10 kg nitrogen application over control, while no significant difference in weight and number of grain per pod, test weight and moisture percentage was observed with nitrogen application.

More number of flowers and pods per plant were found with application of phosphorus over control. But no marked difference between different doses of P_2O_5 was noticed (Valaunathan 1947, Patro 1949, Khot, 1958). A linear increase in length, weight, number of grains, weight of grains per pod and the test weight was found with increasing doses of P_2O_5 while there was no clear effect of phosphorus on moisture percentage in soybean seeds.

Among second order interactions, when phosphorus was applied with wider spacing, the number of flowers and pods were increased. The phosphorus when applied in combination with nitrogen, reduced the moisture content in seeds thus indicating the early maturity of the crop.

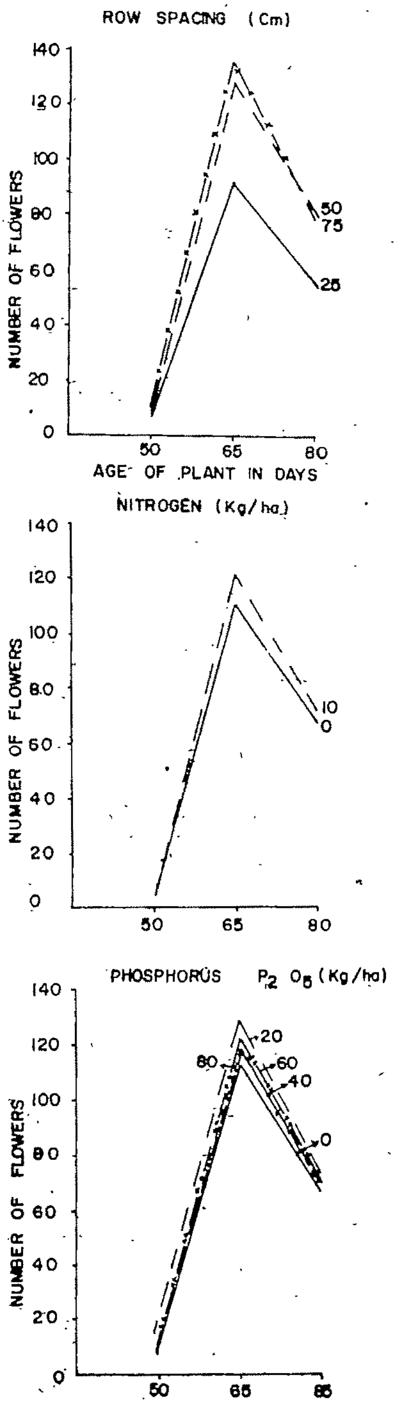
ABSTRACT

Pod development is the main contributing factor in deciding the final yield of any crop. Soybean being not so popular in India, little work has been done on this crop. Therefore, the present experiment was carried out to provide informations regarding pod formation in soybean as affected by plant population and fertility levels. The number of flowers and pods per plant, weight, number of grains and weight of grains per pod were significantly increased with 50 and 75 cm. over 25 cm. row spacing, while reverse was true with test weight and moisture percentage in seeds. The application of nitrogen significantly increased the number of flowers per plant, length of pod and weight of grains per pod, while number of grains per pod, number of pod per plant, weight per pod, test weight and moisture percentage were not markedly influenced. A linear increase in the number of flowers and pods, length, weight, number of grains and weight of grains per pod and test weight of seeds was found with P_2O_5 application. The phosphorus application did not affect the moisture percentage in seeds at the time of harvesting the crop. The initiation of flowering was observed at 50 days after sowing which was completed at 65 days. The pod formation was observed at about 60 days after sowing and a linear increase in the number of pods per plant was observed upto 80 days after sowing.

REFERENCES

1. Burnside, O. C. & Colville, W. L. 1964. Yield components and composition of soybeans as affected by mechanical, cultural and chemical weed control practices. *Agron. Jour.*, **56** : 348.
2. Khot, M. A. 1958. Effect of harmone (2, 4—D) and phosphate with two seed rates of Pea T. 163. Thesis for M. Sc. (Ag) degree of Agra University.
3. Lathwall, D. J. & Evans, C. E. 1951. Nitrogen uptake by soybeans at successive stages of growth. *Agro. Jour.*, **43** : 264-270.
4. Lehman, W. F. & Lambert, J. W. 1960. Effect of spacing of soybean plant between and within rows on yield and its components. *Agro. Jour.*, **52** : 84-86.
5. Patro, C. 1949. Effect of phosphate alone and in combination with N, K on growth and yield of field peas. Thesis for Assoc. I.A.R.I., New Delhi.
6. Valaunathan, T. 1947. Phosphate manuring of grains. Thesis for Assoc. I.A.R.I., New Delhi.

Fig. 1 NUMBER OF FLOWERS PER PLANT

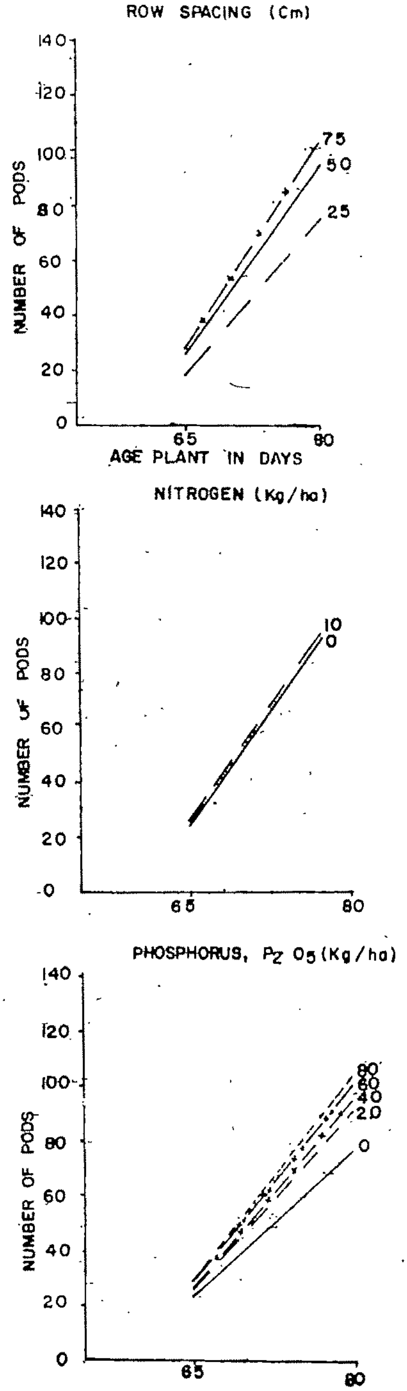


ROW SPACING (Cm)

NITROGEN (Kg/ha)

PHOSPHORUS P₂O₅ (Kg/ha)

Fig. 2 NUMBER OF PODS PER PLANT



ROW SPACING (Cm)

NITROGEN (Kg/ha)

PHOSPHORUS, P₂O₅ (Kg/ha)

Abstract of Theses

NEPHRITIS SYNDROME IN POULTRY
II. PRODUCTION OF URAEMIA SYNDROME BY SODIUM CHLORIDE*

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Introduction

Nephritis syndrome has been variously termed by different authors, such as, Pullet disease, Blue comb (Barger *et al,* 1958), Messy vent (Gray, 1944), Avian Bright's disease (Selye, 1943) and Avian Monocytosis (Winterfield, 1964). Inspite of the considerable information in the literature, the etiology of these diseases in poultry appears to be obscure and there is no unanimity of views amongst authors on this subject. For instance, Selye (1943) explained the role of sodium chloride (Nacl) in experimentally produced nephrosclerosis in poultry, Frischbier and Rindfleisch (1948) suggested Nacl as predisposing factor in the causation of degenerative nephrosis in poultry. The possibilities of virus infection in avain nephrosis have, however, been also suggested by Cosgrove (1962). While, Cumming (1962-63) reported isolation of an aberrent strain of infections Bronchitis virus from the outbreak of 'Uraemia' in Poultry. The association of nephritis in an outbreak with respiratory signs was further observed by Newton and Simmons (1963).

The present report deals with the experimental studies designed to elucidate the role of Nacl alone and or in combination with suspected filterable agent in the development of nephritis of poultry. It is however, primarily concerned with the description of the pathoanatomical changes and biochemical alteration in respect to uric acid level in blood of experimental chicks.

Materials and Methods

The White Leghorn healthy chicks between 4 to 6 weeks age groups, weighing 150 to 250 gm. were made available from the poultry farm, U.P. College of Veterinary Science and Animal Husbandry, Mathura (India). Throughout the experiment all the chicks were fed with poultry mash having 40% maize, 26% wheat bran, 20% groundnut cake, 2% calcium carbonate, 1% bone meal, 0·5% common salt, 0·5% shark liver oil (100% total).

The chicks prior to the start of experiment were observed for four days for any clinical disorder. During the pre-experimental period, the uric acid level of pooled blood in each group was estimated according to the procedure recommended by Harrison (1949) for Folines method. Subsequently, the blood uric acid estimation of chicks in different experimental groups was carried out at weekly intervals in Ist, 2nd and 4th week.

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* Taken in part from thesis submitted by senior author in partial fulfilment of the requirements of M. V. Sc. degree in Pathology (1966), Agra University, Agra (India).

For intra peritoneal inoculation of chicks, the sixth passaged embryonated egg material was used. This was isolated on embryonated eggs by combined chorioalantoic route, from kidneys exhibiting lesions under natural infection (unpublished data).

The particulars of the experiments designed to determine the infectivity of embryonated egg passaged material alone and in combination with sodium chloride of various concentrations, and role of sodium chloride alone of varied concentrations given to different groups of chicks, have been detailed in table 1.

TABLE 1

Details of Different Experiments.

Sl. No.	Experiment No.	Designation of Group	Total Chicks	Age	Control	Particular of experiment
1.	Exp. I	'IN'	8	4 weeks	3	All chicks received intra-peritoneal (I/P) inoculation of 0·5 ml. SFA.
2.	Exp. II	A	7	6 weeks	3	In addition to 1 ml. I/P of SFA, chicks received 0·3% Nacl in drinking water.
		B	8	4 weeks	3	In addition to 1 ml I/P of SFA, birds received 0·1% Nacl in drinking water.
3.	Exp. III	A_1	10	6 weeks	5	Chicks received 0·9% Nacl in drinking water.
		B_1	8	4 weeks	4	Chicks received 0·1% Nacl in drinking water.

SFA=Suspected filterable agent from amino-allantoic fluid of 6th egg passage.

The chicks maintained under various experiments along with controls were observed clinically for four weeks. The autopsy was done on all the chicks which died during the experiment or sacrificed till the termination of the experiment.

The sections were made (5 to 7μ) from paraffin embeded 10% formaline fixed kidney tissues and stained by the conventional Haematoxylin and Eosin method.

RESULTS

Experiment I—Group 'IN'

Prior to the experiment, the uric acid level in blood on an average was 4·4 mgm/100 cc. of blood. Subsequently an increase of uric acid level of blood was observed which ranged from 3·8 to 6·8 mgm/100 cc. of blood (Fig. 1).

The birds of this series, did not manifest any clinical symptoms and were sacrificed at the end of fourth week of the experiment.

Grossly, the kidneys in all the birds were enlarged, dark red with distinct tubular marking on the surface.

Histopathologically, the lesions were characteristic of tubular degeneration. The cells of proximal and distal convoluted tubules were markedly swollen, almost encroaching the tubular lumen with a characteristic granular cytoplasm (Fig. 2). The cellularity of the glomerular tufts in all the cases was slightly increased. The focal interstitial infiltration with mononuclear cells was present in two chicks. No significant vascular changes were noticed.

Experiment II—Group 'A'

The uric acid level in blood of the chicks under this group was 11·7 mgm/100 cc. of blood during Ist week against 4·4 mgm/100 cc. of blood prior to the experiment (Fig. 1).

All the chicks in this group revealed symptoms of acute illness within 48 hours of the experiment, featuring dullness with gasping respiration, ruffled feathers, distended crop with fluid in some cases and marked muscular weakness (Figs. 3 and 4). These were sacrificed at the height of illness and autopsied.

Grossly, the kidneys were enlarged, light to dark red and distinct surface tubular markings. The ureters in a few cases were swollen containing milky white urates and peticheal haemorrhages on thigh muscles.

Histopathologically, lesions were characterised by shrunken glomeruli, distended Bowman's space (Fig. 5) and mild hypeplasia of epithelium lining the capsule. The tubular epithelium at places was detached and the lumen filled with cellular debris, red blood cells, albuminoid material and eosin stained urates.

Group 'B'

The uric acid level in blood of chick in this group in different weeks ranged from 3·8 to 6·7 mgm/100 cc. of blood as against 4·5 mgm/100 cc. of blood in pre-experimental period (Fig. 1).

The birds did not manifest any clinical symptoms and were sacrificed at the end of the experiment.

The macroscopic and microscopic changes were almost similar to those observed in the chicks under group 'IN' except the marked focal interstitial infiltration of mononuclear cells in all the cases.

Experiment III—Group 'A_1'

The uric acid level in chicks of this group on an average was 14·4 mgm/100 cc. of blood as against 3·8 mgm/100 cc. of blood in pre-experimental period (Fig. 1).

The clinical manifestations exhibited by chicks were comparable to the symptoms of 'uraemia' observed in chicks of group 'A', except that the symptoms were more pronounced, particularly the muscular weakness (Fig. 4). Four chicks died on the third day while the rest died within a week.

The naked eye lesions were almost similar as observed in chicks of group 'A' except in most of the cases swollen ureters filled with fluid containing urates were distinct (Fig. 6). The cardiac dilatation and hydropericardium was invariably present in these cases.

Microscopically, the lesions were characterised by shrunken glomeruli with distended Bowman's space having hyperlastic epithelial lining of the capsule. The cells, particularly of proximal and distal convoluted tubules were under varied stages of degeneration featuring granular and vacuolated cytoplasm. The epithelial lining of the tubules was detached and at places lumen contained cellular debris, hyaline casts and red blood cells.

Group 'B_1'

The uric acid level in blood of this group in different weeks ranged from 5·0 to 6·8 mgm/100 ml. of blood as against 4·7 mgm/100 cc. of blood during pre-experimental period.

The chicks under this group did not manifest any clinical symptoms of illness. No significant gross changes and microscopic alterations except albuminoid degeneration in a few cases were noticed.

Control

The uric acid level in this group of chicks in different weeks of the experiment ranged from 2·8 mgm to 5·0 mgm/100 ml of blood against 3·5 mgm/100 ml of blood during pre-experimental period (Fig. 1).

The birds of this series were sacrificed and no significant gross and microscopic alterations could be noticed.

DISCUSSION

There are not much information available in the literature, regarding the normal values of uric acid contents of the blood in poultry and its variation in disease condition, particularly in relation to nephritis. However, Dunlap (1932) mentioned the normal blood uric acid contents of chicks to be 4·41 mgm/100 ml of blood. In the chicks of present experimental series, the normal uric acid content of blood ranged from 2·3 to 5·0 mgm/100 ml of blood which showed a significant rise amongst chicks of all the groups, except the ones designated under 'B_1' and control groups. Newton and Simmons (1964) induced chronic nephritis in chicks by inoculating second egg yolk passaged material intraperitoneally. They also observed in their cases a rise of uric acid level ranging from 6·0 to 11·6 mgm/100 ml of blood. It would be seen from the present experiments, that chicks of group 'IN' did not develop chronic nephritis after the intra-peritoneal inoculation of sixth egg passaged material, though changes characterised by albuminoid degeneration in kidneys with rise in uric acid level in blood (3·8 to 6·8 mgm/100 ml of blood) were noticed. It might also be inferred from these results that the blood uric acid level was in some way related to the functional status of the kidneys. These observations were further supported by the results of significantly high uric acid level in the chicks of group A and A_1 which received one ml of SFA along with 0·3% Nacl and 0·9% Nacl alone in drinking water respectively.

It might be interesting to note that unlike the changes in blood and kidneys of group 'IN' high uric acid level in blood along with marked nephrosis was present in chicks of group 'A'. Such a striking difference in the kidney lesions and blood uric acid content though might be expected under the influence of the combined effects of SFA and 0·3% Nacl in water, it would be rather difficult to evaluate the relationship of both these factors from the present limited studies.

In experiment III, the chicks of group 'A_1' exhibited, surprisingly, the highest level of uric acid in blood (14·0 mgm/ml of blood) along with the manifestations of "Uraemia" and nephrotic lesions. These results offered support to the views of Beilharz and McDonald (1960) who opined that uraemia in poultry might develop by altering sodium and potassium balance in the diet, chiefly by the increased concentration of sodium chloride. Thus the status of hyperuricaemia in poultry appears to be related with the sodium chloride intake and might further explain the hypothesis that the avian subject is much more dependent on the balanced sodium chloride intake than mammals.

SUMMARY

Hyperuricaemia in blood and characteristic clinical symptoms of 'Uraemia Syndrome' in poultry were produced by giving 0·9% sodium chloride alone and 0·3% sodium chloride with intra-peritoneal inoculation of suspected filterable agent. The pathoanatomical changes and clinical manifestations in different groups have been described. The changes in uric acid level of blood have been discussed.

ACKNOWLEDGEMENT

Thanks are due to Sri C. V. G. Choudary, Principal, U.P. College of Veterinary Science and Animal Husbandry, Mathura for providing facilities.

REFERENCES

1. Barger, E.H., Card, L.E. & Pomeroy, B.S. 1958. Diseases and parasites of Poultry, 5th Ed. Lea & Febiger Philadelphia.
2. Beilharz, R.G. & Mc Donald, M.W. 1960. *Aust. Vet. J.* **36**: 89-90.
3. Cosgrove, A.S. 1962. Avian Dis. **3**: 385-390.
4. Cumming, R.B. 1962. *Aust. Vet. J.* **38**: 554.
5. Cumming, R.B. 1963. *Aust. Vet. J.* **39**: 145-147.
6. Dunlap, G.L. 1932. *J. Amer. Vet. Med. Ass.* **80**: 880-885.
7. Frischbier & Rindfleisch 1948. *Vety. Bull.* **20**: 1038.

8. Gray, E. 1946. Diseases of poultry 2nd Ed. London Crosby Lockwood & Son Ltd. 20 Tudor Street, E.C. 4.
9. Harrison, G.A. 1949. Chemical Methods in clinical medicine 3rd Ed. J & A Churchill Ltd., 104 Gloucester Place W.I. London.
10. Newton, L.G. & Simmons, G.C. 1963. *Aust. Vet. J.* **39**: 135-139.
11. Selye, H. 1943. *J. Amer. Vet. Med. Ass.* **103** : 140-143.
12. Winterfield, R.W. & Hitchner, S.B. 1962. *Amer. J. Vet. Res.*, **23**: 1273-1279.

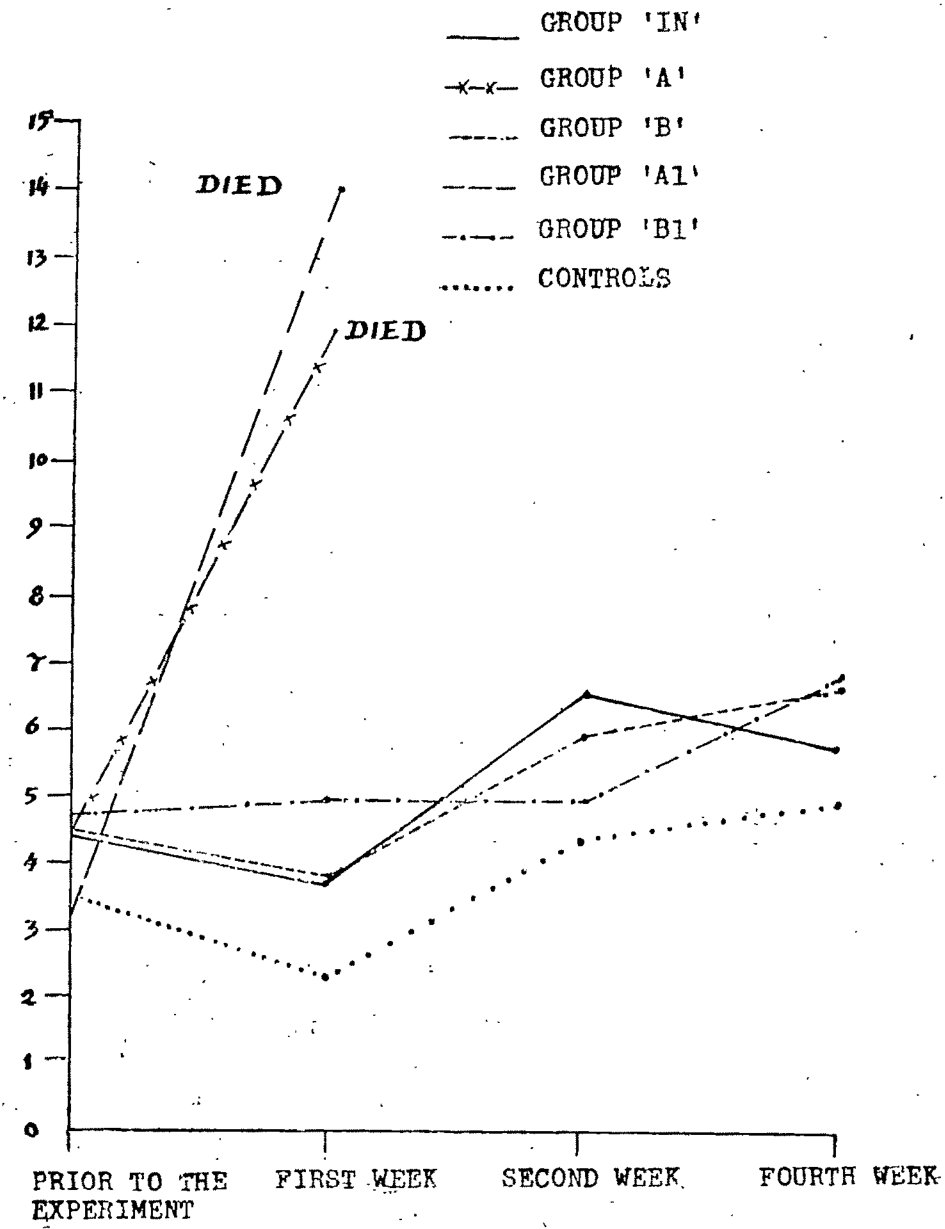

FIG. 1 AVERAGE URIC ACID LEVEL IN BLOOD OF EXPERIMENTAL AND CONTROL CHICKS.

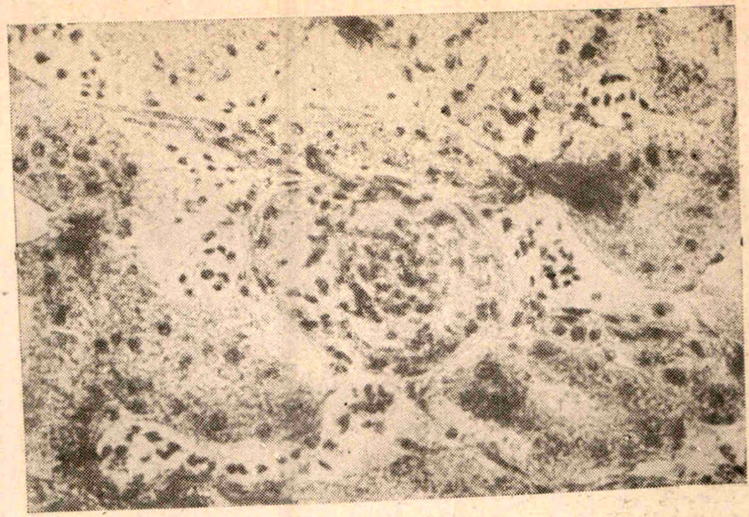

Fig. 2. Experiment I Group 'IN' Note marked swelling of proximal and distal convoluted tubules almost encroaching the lumen with characteristic albuminoid degeneration. H & E x 420.

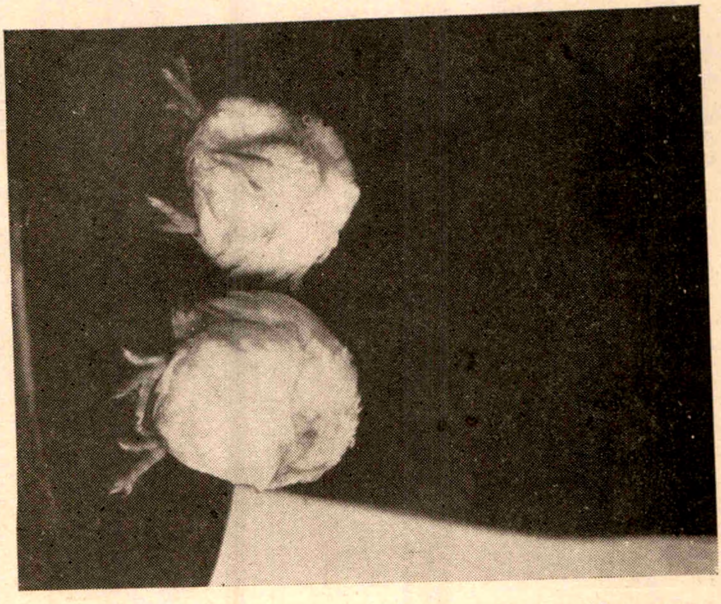

Fig. 3. Experiment II Group A. Chicks showing acute symptoms with pronounced muscular weakness.

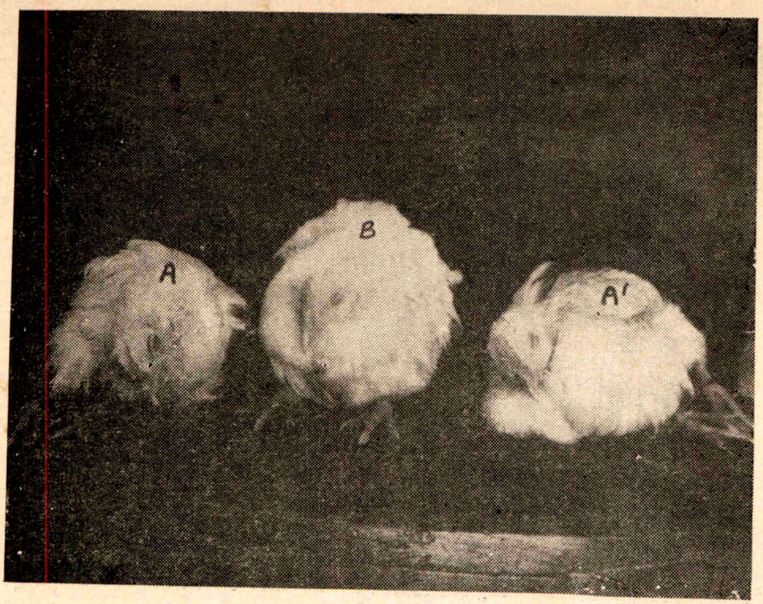

Fig. 4. Experiment II Group A. Chicks showing acute symptoms.
The chicks marked A and A′ belong to experiment III group A_1 and B to experiment II group A.

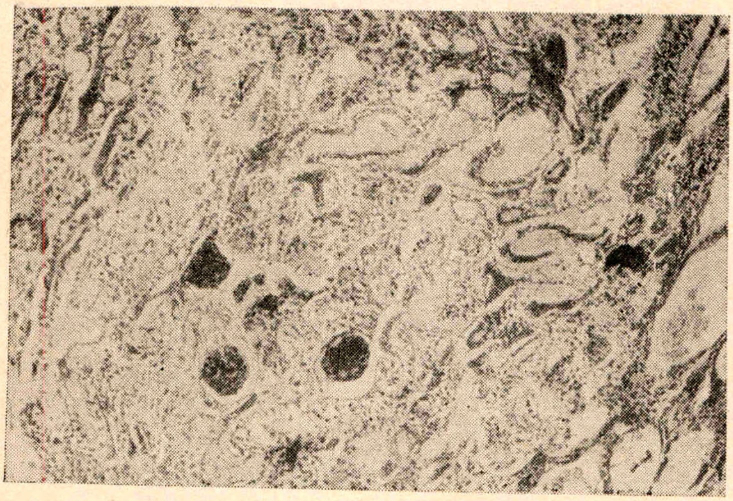

Fig. 5. Experiment II Group A. Glomeruli showing shrunken tufts distended Bowmon's capsule and desquamated epithelial lining of tubules. H & E x 300.

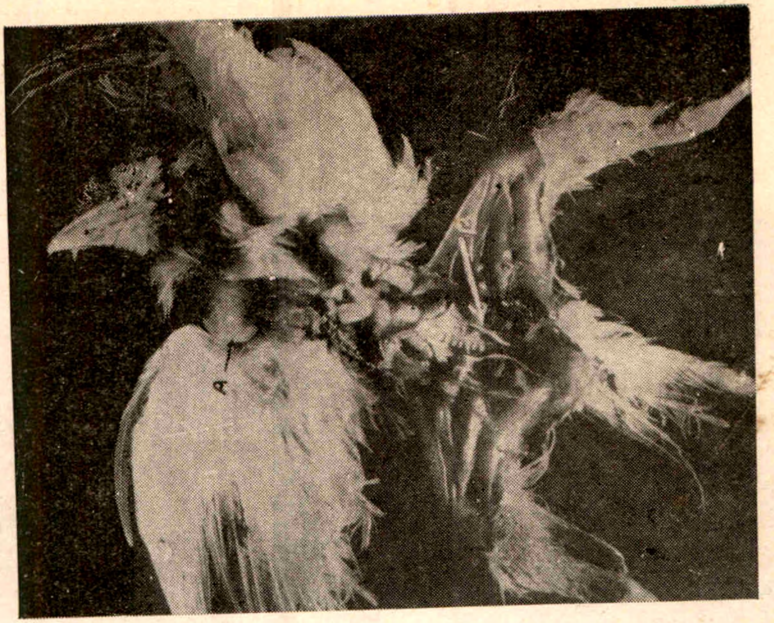

Fig. 6. Experiment III Group A. Distended crop showing oedema at arrow 'A' and uretral dilatation filled with urate at arrow 'B'.

STUDIES ON THE OVULATION AND OVIPOSITION IN SOME INSECTS WITH PARTICULAR REFERENCE TO CORPUS LUTEUM FORMATION[1]

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I. *Philosamia cynthia ricini* (Boisd.) and *Bombyx mori* L.

The two ovaries, each consisting of four polytrophic ovarioles, lie folded upon themselves in the body cavity.

At emergence each ovariole contains many fully developed and chorionated eggs and some eggs without chorion and without nurse cells: a few eggs without chorion and with seven nurse cells are also present.

Precopulation period in *Philosamia cynthia ricini* is between five to twelve hours while in *Bombyx mori* it is twenty minutes to fifty-five minutes.

The copulation period in *Philosamia cynthia ricini* and *Bombyx mori* is ten to twenty and five to twelve hours respectively.

Under normal conditions when the males are provided to the females immediately after emergence the copulation is a prolonged affair but if the males are provided to the females rather late in life, the duration of copulation is not much prolonged due to the progressively increasing pressure of the ovulating eggs inside the oviduct.

The ovulation in both the insects takes place before emergence.

From each ovariole, during ovulation, several eggs descend simultaneously and the emptied follicles of these eggs, in turn, are occupied by the series of the following ones, hence the follicles do not find time to collapse and form a normal corpus luteum until a large number of eggs is discharged.

The ovulation is a steady and continuous process which later becomes continuous along with the oviposition.

Rate of ovulation in mated females is higher than that in virgin females.

The virgin females after twenty-one hours of emergence in *Philosamia cynthia ricini* and eighteen hours in *Bombyx mori* start laying eggs which shows that the copulation is not an essential stimulus for oviposition.

The mated females lay eggs after six hours of copulation in *Philosamia cynthia ricini* and eight hours in *Bombyx mori*. This period has been referred to as the quiescent period.

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[1] This is an abstract of the thesis submitted and approved for the Ph. D. degree of the Agra University in the year 1966.

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The rate of oviposition in virgin females is very slow.

The oviposition in mated females is a steady and continuous process and generally occurs after sunset and stops after four to five days in *Philosamia cynthia ricini* and three to four days in *Bombyx mori*.

The average number of eggs laid during the whole oviposition period by *Philosamia cynthia ricini* is 198·9 while in *Bombyx mori* it is 338·3 eggs per female.

The formation of the corpus luteum has been studied under two conditions *viz*. (a) during partial ovulation and (b) during active oviposition.

Three to twelve hours after emergence in *Philosamia cynthia ricini* and three to nine hours in *Bombyx mori* the ovarioles show an empty space between two oocytes. These gaps which are formed due to the descent of the mature eggs are the corpora lutea formed by more than one follicles because even at emergence more than one eggs are seen to have ovulated which shows that more than one follicles should be involved in the formation of such corpora lutea. During late hours of ovulation these gaps are seen to have obliterated due to the increased rate of ovulation.

During early hours of oviposition there is no corpus luteum formation due to rapid rate of ovulation.

When a large number of eggs is discharged from each overiole, the empty follicles collapse and form a long, narrow and cylindrical compound corpus luteum, which is always colourless.

The corpus luteum of a single follicle is never formed in both the cases.

In *Philosamia cynthia ricini* and *Bombyx mori* gradual cellular degeneration and absorption of the follicular epithelium are studied in detail.

The rate of absorption of the corpus luteum in *Bombyx mori* is more rapid than that of *Philosamia cynthia ricini*.

The early signs of the degeneration of the follicle cells are seen in the late pupal stage when the ovulation has not yet taken place. This establishes the fact that the follicular degeneration starts before the ovulation.

The absorption of the corpus luteum leads to its more or less complete degeneration.

The nurse cells start diminishing as the oocytes mature and as such by the time the chorion is formed around the ova the nurse cells disappear completely and do not take any part in the formation of the corpus luteum.

II. *Musca domestica nebulo* Fabricius

Each of the two ovaries consists of forty-one to fifty-one polytrophic ovarioles, which are profusely tracheated and do not end in terminal filament.

Immediately after emergence the ovarioles do not exhibit egg rudiments. One day after emergence two egg rudiments are distinguished while four days after emergence a third egg rudiment is also observed.

The rate of the development of egg_1 is very rapid while that of egg_2 is comparatively slow until the discharge of egg_1.

The copulation starts twenty to thirty hours after emergence.

The copulation period varies between thirty to forty five minutes and a single mating is enough to enable the female to lay fertilised eggs throughout the life.

Normal preoviposition period is five to eight days.

The egg laying takes place in batches.

After the first egg laying the ovarioles are classified as ovulated, unovulated and immature ones. The ovulated ovarioles have a colourless corpus luteum at the base, the mature ovarioles have a mature cigar shaped egg at the base while the immature ones show an undeveloped basal egg.

The number of the eggs laid in the first batch exactly correspond with the number of ovulated ovarioles having a colourless corpus luteum at the base.

The presence of the unovulated and the immature ovarioles in the same ovary at the same time indicates that all the ovarioles do not ovulate or mature at the same time.

The number of eggs in the successive batches is not constant.

Each fly lays two to nine batches of eggs in the whole life time. The average interval between the successive batches ranges from 1·0 to 1·5 days.

After ovulation a colourless corpus luteum of a single follicle is formed at the base of each ovulated ovariole. This corpus luteum gradually contracts an insignificant mass by the time the egg_2 is ready to ovulate.

The corpus luteum is a colourless structure which within twenty-four hours of ovulation and two days after ovulation develops a yellow colour.

Two days after the first oviposition most of the females lay the second batch of eggs. After the second oviposition the ovarioles are categorised.

The ovarioles with a longer corpus luteum having a yellow ring at the base have ovulated a second egg.

The ovulation of the second egg results in the formation of the second corpus luteum over the remains of the first contracted one.

After every successive oviposition the ovulation of an egg leads to the formation of corpus luteum of a single follicle which contracts gradually. The formation of the corpus luteum involves the loss of the cellular nature of the follicle and the contraction of the tunica propria. In the early stages of the corpus luteum formation a compressed lumen indicating the passage of the egg is seen. This lumen gets obliterated in due course of time.

The first contracted corpus luteum after the formation of the second one is distinguished by the presence of very much folded and thickened tunica propria enclosing very weakly staining cytoplasm with a few weakly basophilic chromatin patches.

Due to the rapid rate of degeneration never more than two corpora lutea are observed simultaneously.

The degeneration of the follicle cells is similar to that of *Philosamia cynthia ricini.*

The nurse cells disappear before the chorionation of the oocyte and, therefore, do not take any share in the corpus luteum formation.

III. *Epilachna vigintioctopunctata* Fabricius

About forty to forty-nine acrotrophic ovarioles comprise each of the two ovaries, which lie ventro-dorsally in the abdominal cavity. Each ovariol ends in a terminal filament.

Immediately after emergence the ovarioles do not exhibit clear distinction between the germarium and the vitellarium. Four days after emergence a single egg rudiment is observed in the vitellarium; second and the third egg rudiments appear five and six days after emergence, respectively.

The rate of the development of egg_2 is slow until the discharge of egg_1.

The copulation commences two days after emergence. The duration of copulation ranges between one and a half to five hours and is repeated many times throughout the life cycle along with the oviposition.

Normal period of preoviposition is nine to thirteen days. Like the *Musca domestica nebulo,* in this case also the ovulation takes place sometime before the oviposition and a single egg is ovulated by each ovariole at a time. The oviposition takes place in batches.

After the first egg laying the gradation of the ovarioles shows that some of them possess a colourless corpus luteum at the base, these are the ovulated ovarioles. Other ovarioles have either a mature or an undeveloped basal egg. The former are designated as unovulated and the latter as immature ovarioles.

The number of the eggs laid in the first batch exactly corresponds to the number of ovulated eggs having a colourless normal corpus luteum at the base.

The presence of the unovulated and the immature ovarioles along with the ovulated ones indicates that all the ovarioles do not ovulate and mature simultaneously.

Each female lays seven to nineteen batches of eggs in the whole life time. The number of eggs goes on decreasing in the successive batches. The average interval between the successive batches ranges from 1·5 to 2·5 days.

After ovulation, at the base of each ovulated ovariole, a colourless corpus luteum is formed which contracts to an insignificant body after two days of ovulation. This corpus luteum similar to that of *Musca domestica nebulo* is colourless immediately after and within twenty-four hours of ovulation but develops a yellow pigment after two days of ovulation.

Two days after the first oviposition a second batch of eggs is laid by most of the females; their ovarioles are categorised. The ovarioles with a longer corpus luteum having a yellow ring at the base have ovulated a second egg. After the ovulation of the second egg a second corpus luteum is formed over the remains of the first contracted and pigmented one. After each subsequent oviposition the ovulation of an egg is followed by the formation of a corpus luteum of a single follicle which contracts gradually.

During the corpus luteum formation the cellular nature of the follicle is lost and tunica propria gets folded. In early stages of corpus luteum formation a compressed lumen is visible.

Due to the rapid rate of degeneration, in each ovariole only two corpora lutea are observed simultaneously.

IV. *Gryllodes sigillatus* (Walker)

Two profusely tracheated ovarioles lie ventrodorsally on either side of the proctodaeum in the abdominal cavity. Each ovary consists of eighty-eight to ninety panoistic ovarioles.

The rate of the development of egg_1 is rapid while that of egg_2 increases only by the time egg_1 leaves its follicle.

The normal preoviposition period ranges between nine to twelve days.

The ovulation takes place sometimes before the oviposition and a single egg is ovulated from each ovariole at a time. The oviposition takes place in batches. After the first batch of eggs is laid, the ovarioles are categorised as ovulated and unovulated ones.

Degenerated or the abnormal ovarioles are mostly observed in those females in which the preoviposition period exceeds the normal time or the oviposition does not occur at all.

The number of eggs laid in the first batch exactly corresponds to the number of ovulated ovarioles having a normal colourless corpus luteum at the base.

The number of eggs in successive batches is not constant. Each female lays from nine to nineteen batches of eggs during the whole oviposition period. The average interval between the successive batches varies from 1·5 to 2·5 days.

After ovulation of an egg a corpus luteum of a single follicle is formed at the base of each ovulated ovariole. The corpus luteum contracts to an insignificant mass after two days of ovulation.

Immediately after ovulation the corpus luteum is a colourless structure but after two days it develops a yellow pigment.

After two days of the first oviposition a second batch of eggs is laid by most of the females; again, their ovarioles are categorised.

The ovarioles with corpora lutea having a yellow ring at the base near the pedicel have ovulated a second egg.

Not only the ovulation of the egg but its resorption inside the follicle also results in the formation of a structure more or less similar to the normal corpus luteum. The structure formed by the resorption of the oocyte inside the follicle is referred to as the resorption body. Histology of the resorption body differs from that of the normal corpus luteum.

The resorption body may also be observed in certain cases over the remains of the contracted and pigmented corpus luteum. This indicates that in that particular ovariole the egg$_1$ developed normally and after its discharge a normal colourless corpus luteum was formed which contracted and developed a pigment, while egg$_2$ did not undergo a normal development but formed the resorption body.

At the base of each ovulated ovariole after each subsequent ovulation of a normal egg a colourless corpus luteum of a single follicle is formed which gradually contracts.

Due to the rapid rate of degeneration of the corpus luteum never more than two corpora lutea were observed simultaneously.

The degeneration of the follicle cells is similar to that of *Philosamia cynthia ricini.*

THE STUDY OF LIGHT ABSORPTION IN XO_3 IONS IN STATE OF AQUEOUS SOLUTION*

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ABSTRACT

Spectrophotometric investigations were carried out on the absorption spectra of nitrates, carbonates, bi-carbonates, chlorates, bromates and iodates in state of aqueous solution in the region 1850-3600 Å. Two bands, one weak at 300 mμ and the other strong one at 200 mμ have been recorded in the case of nitrate ion. Two weak bands have also been observed in the case of carbonate and bicarbonate ions at 270 and 217 mμ. In the case of halates only one intense band near 200 mμ has been observed. Effects of dilution and cations have also been studied. Both theoretical and experimental evidences have been cited for their assignments to different intra-molecular transitions. Optical and magnetic birefringence and magnetic anisotropy have been explained on the basis of the observed absorption.

INTRODUCTION

Though the absorption spectrum of nitrate ion has been studied in some detail[11],[18] that of other XO_3 ions[5],[13] has not been studied systematically. In the absence of any knowledge of electronic energies of the nitrate ion Krishnan and Guha[4] suggested photodissociation of NO_3^- into NO_2^- and O as the cause of the two bands of the nitrate ion. The present auther, however, could not detect the presence of the nitrite ion due to photodissociation by colorimetric method. Pure nitrate melts when tested for nitrite ion by Smith and Boston[16], gave negative results. It must be remembered that in the melts the concentration of the nitrite ion formed as a result of photodissociation should be more than detectable. Previous workers also failed to explore the exact position of the absorption bands of XO_3 ions. Consequently the present investigation was carried out using improved technique with spectrophotometer[18]. The results have been explained in terms of LCAO—MQ calculations for energy and oscillator strengths of the transitions giving rise to observed bands. These results have also been used to explain optical birefringence, magnetic birefringence and magnetic anisotropy of the crystals containing XO_3 ions.

EXPERIMENTAL

Measurements were carried out with Hilger's Uvispek spectrophotometer on the aqueous solutions of the following salts:

1. Nitrates of lithium, sodium, potassium, ammonium, silver, magnesium, cadmium, strontium, calcium, barium and alluminium.

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* Ph. D. thesis submitted in 1963 and degree awarded in 1964.

** The work was conducted in Physical Laboratories, Agra college, Agra 1959-1963.

2. Carbonates and bicarbonates of sodium, potassium and ammonium.
3. Chlorates, bromates and iodates of sodium, potassium and barium.

All the salts were of AR. grade. Triple distilled water was used for making solutions.

Results and Discussion

The important results obtained in the present investigation have been discussed below:

1. *Absorption Spectra*

(a) *Nitrate ion*—Nitrate ion is known to have planar structure and D_{3h} symmetry[2],[19]. Following Walsh[23], McGlynn and Kasha[7], McEwen[6] and Strickler and Kasha[17], LCAO—MO treatment of the nitrate ion yields three possible transitions —$n \rightarrow \sigma^*$, $n \rightarrow \pi^*$ and $\pi \rightarrow \pi^*$. $n \rightarrow \pi^*$ transition is a symmetry forbidden one with symmetries $A_1' \rightarrow E''$ and $A_1' \rightarrow A_1''$ having energy $\sim$4·40ev. The observed 300mμ band having energy $\sim$4·10ev and poor intensity (molar extinction coefficient $\varepsilon_{max} \sim 20$ and oscillator strength $f \sim 10^{-4}$) may be assigned to this transition in complete agreement with Strickler and Kasha[17]. $\pi \rightarrow \pi^*$ transition is $^1A' \rightarrow E'$ symmetry allowed one with energy 6. ev. This has been identified with intense band near 200 mμ having energy 6·17 to 6·23 ev in different nitrates and $\varepsilon_{max} \sim 10^3$ and $f \sim 10^{-1}$. $n \rightarrow \sigma^*$ transition which is expected to have energy less than that of $n \rightarrow \pi^*$ one could not be observed.

(b) *Carbonate and bicarbonate ions*—X-ray[8], infrared[15] and magnetic[9] studies show that hydrogen in bicarbonate ion does not affect the carbonate group. Hence carbonate and bicarbonate ions have the same D_{3h} symmetry[8]. LCAO—MO calculations similar to that of nitrate ion show that only same three transitions are possible. $n \rightarrow \sigma^*$ transition which is expected to have energy less than that of $n \rightarrow \pi^*$ transition may be indentified[13] with the weak band ($\varepsilon_{max} \sim 10^{-1}$ and $f \sim 10^{-6}$) located near 270 mμ. Forbidden $n \rightarrow \pi^*$ transition may be identified[13],[14] with the 200mμ band having $\varepsilon \sim_{max} 10^1$ and $f \sim 10^{-4}$. $\pi \rightarrow \pi^*$ transition could not be observed as it may be located below 185mμ the lower limit of the instrument.

(c) *Chlorate, bromate and iodate ions*—Only one intense band ($\varepsilon_{max} \sim 10^3$ and $f \sim 10^{-1}$) has been observed near 200mμ. Constructing molecular orbitals of 26 valence electrons as LCAO appropriate to the C_{3v} symmetry by the method of McGlynn and Kasha[7], this band may be assigned to the transition which raises an electron from an orbital on oxygen atom to a strongly antibonding orbital on the halide atom. The shift of the band towards shorter wavelengths coupled with the rise in intensity with progressive dilution of the aqueous solution suggest charge transfer in the ion itself due to the transition. This band may be due to the $\pi \rightarrow \pi^*$ transition.

2. *Effect of Cation on the Absorption Spectrum*

It is interesting to note that the energies of the bands vary as Z/r, where Z and r are charge and radius of the cation respectively. This may be explained[11] by considering Coulomb and overlap forces in the ionic solution.

3. *Effect of Dilution on the Absorption Spectrum*

Both $n \rightarrow \pi^*$ and $\pi \rightarrow \pi^*$ transitions have been found to shift to shorter wavelengths[11] with dilution which may be explained as follows. In XO_3 ions the n and π orbitals are predominently situated on the oxygen atoms while the π^* orbitals on X atoms. These transitions remove an electron from n or π orbital and place it in strongly antibonding π^* orbital. This results in a decrease in the electron density in the region where n or π orbitals are situated. A hydrogen bond formed to the oxygen atom having n or π orbital places a positive charge near it, making it more difficult to remove the electron. This causes an increase in the energy of these transitions with progressive dilution.

4. *Optical Birefringence*

The refractive indices of crystals containing XO_3 ion can be represented by a formula of the type[20]

$$n^2 = -D\lambda^2 + A + B\lambda^{-2} + C\lambda^{-4} \qquad \text{..(1)}$$

where the symbols have usual meaning. By elaborate least square method treatment, the constants A, B, C and D were evaluated from the experimental values of n and λ. The calculated values of n compare very well with the observed ones. Further from the fundamental consideration of the vibrations of the oxygen atoms in the XO_3 ion, the absorption regions in infrared and ultraviolet were calculated which were in complete agreement with observed infrared[15] and Ultraviolet[11] absorption.

5. *Magnetic Anisotropy*

According to Van Vleck's theory[22] the magnetic anisotropy of the molecule, ΔK, is proportional to $\left(\frac{1}{\nu_{II}} - \frac{1}{\nu_I}\right)$, where ν_I and ν_{II} correspond to mean absorption frequencies parallel and perpendicular to the plane of the molecules, respectively. Thus the anisotropy ΔK will be positive or negative depending on whether ν_I is greater or less than ν_{II}. In case of carbonate and nitrate ions ν_{II} is greater than ν_I, but vice versa in the case of chlorate, bromate and iodate ions. Hence the observed negative anisotropy of nitrate and carbonate ions and that positive of chlorate, bromate and iodate ions, are explained[10,21].

6. *Magnetic Birefringence*

Magnetic birefringence is intimately connected with magnetic anisotropy. The magnetic birefringence Cotton Mouton Constant C_m is given by[3]

$$C_m = \frac{(n_0^2-1)\ (n_0^2+2)}{30 n_0\ \lambda\ KT} \quad \frac{R\varepsilon - R\omega}{2R\omega + R\varepsilon} N.\ \Delta\ K \qquad \text{..(2)}$$

where n_0 is the mean refractive index, k is the Boltzman constant λ is the wavelength of the electromagnetic radiation, T is the absolute temperature, R_ϵ and R_ω are molar refractivities and ΔK is the magnetic anisotropy, $K_{II}-K_{I}$.

The sign of C_m depends upon that of $R_\epsilon - R_\omega$ and ΔK. The former is negative but the sign of the later depends on the structure of the ion, as discussed in the preceeding section. Consequently, C_m must be positive for nitrate and carbonate ions and negative for chlorate, bromate and iodate ions. This is what has been observed.[1]

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REFERENCES

1. Chinchalker, S. W. 1931. *Indian J. Phys.*, **6** : 165, 563; 1932, *Indian J. Phys.*, **7** : 317.
2. Herzberg, G. 1960. Molecular spectra and Molecular Structure, Part II., (D. Van Nostrand Company, Inc., New York).
3. Jagannatham, A.V. 1951. *Proc. Raj. Acad. Sci.*, **2** : 10.
4. Krishnan, K.S. & Guha, A.C. 1934. *Proc. Ind. Acad. Sci.*, **1** (4) : 242.
5. Ley, H. & Arends, B. 1932. *Z. Phys. Chem.*, **B17** : 192.
6. McEwen, K.L. 1961. *J. Chem. Phys.*, **34** : 547.
7. McGlynn. S.P. & Kasha, M. 1956. *J. Chem. Phys.*, **24** : 481.
8. Mooney, C. L. 1932. *Phys. Rev.*, **39** : 861.
9. Mookherji, A. 1951. *Raj. Univ. Studies*, **1A** : 5.
10. Mookherji, A. 1953. *Raj. Univ. Studies*, **2A** : 137.
11. Mookherji, A. & Tandon, S. P. 1962. *Indian J. Phys.*, **36** : 211, 344; 1965, *Indian J. Phys.*; **39** : 137, 396, 569.
12. Mookherji, A. & Tandon, S. P. 1964. **38** : 174, 278.
13. Mookherji, A. & Tandon, S. P. 1965. *Indian J. Pure and Appl. Phys.*, **3** : 497; 1965. *Z. angew Phys.*, **22** : 86.
14. Mookherji, A. & Tandon, S.P. 1966. *Proc Phys, Soc Japan*, **21**, 1176.
15. Ramdas, A.K. 1953. *Proc. Ind. Acad. Sci.*, **37** : 441.
16. Smith, G.P. & Boston, C.R. 1961. *J. Chem. Phys.*, **34** : 1396.
17. Strickler S. J. & Kasha, M. 1964. Molecular orbitals in Chemistry, Physics and Biology, Academic Press, Inc., New York, 241.
18. Tandon, S.P. 1961. *Raj. Univ. Studies*, **A9** : 69
19. Tandon, S.P. 1962. *Proc. Raj. Acad. Sci.*, **9** : 3.
20. Tandon, S.P. 1965. *Z. Phys. Chem.*, **228** : 145.
21. Tandon, S. P. 1965. *Z. Phys. Chem.*, **223** : 151.
22. Van Vleck, J.H. 1932. Electric and Magnetic susceptibility, (Oxford).
23. Walsh, A.D. 1953. *J. Chem. Soc.*, 2301.

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EFFECT OF PLANT GROWTH REGULATORS ON SEX-EXPRESSION, FRUIT DEVELOPMENT AND QUALITY IN THE WATERMELON (*CITRULLUS VULGARIS* SCHARD)

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Sex-expression and sex-ratio in cucurbitaceae have generally been of considerable interest for study. The effects of environment, light and neutran radiation in changing the sex-expression in cucurbits have been reported by recent research worker (1,12-15) while others (2-9,11) have recorded the significant effect of plant growth regulators on the sex-expression and sex-ratio in cucurbitaceous crop plants. Porter *et al.* (10) stated that high quality in watermelon was largely dependent upon a high total sugar content which consequently improved the quality of watermelon. They also reported that total sugars represented 85 per cent total soluble solids. The present study was made to find out whether these different characters under study have any response to plant growth regulators under Kanpur conditions. This paper is, thus, an attempt to evaluate the effect of various plant regulator sprays on sex-expression, sex-ratio, size and quality of the watermelon (*Citrullus vulgaris* Schard).

MATERIALS AND METHODS

The seeds of Watermelon, variety Sahjahanpuri, were sown in the field on January 20, 1962. Seedlings at 2-3 leaf stage were sprayed two times at seven days interval with different concentrations (50,100,150,200 and 250 ppm) of MH, IAA and NAA-solutions with the help of an automizer. The control plants were sprayed with distilled water. The whole lot of all treatments was replicated four times. Five plants were randomly selected from each treatment, for study.

Pollen grains were stained with glycerine jelly and pollen fertility was recorded five times during the season. Soluble solids determination was made by means of Hand Zeiss Refractometer which is sufficiently accurate for measuring the relative sweetness. The samples of juice for refractometer tests were taken from the central flesh between blossom and stem ends.

RESULTS AND DISCUSSION

Sex-expression and Sex-ratio—The number of female and male flowers in each treatment was calculated and sex-ratio was worked out. The results are summarized in table 1.

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TABLE 1

Effect of plant regulators sprays on the number of female and male flowers and the sex-ratio

Treatments	Average female flowers	Average male flowers	Total number of flowers	Ratio of female to male flowers
Control	8·5	86·11	94·61	1 : 10·13
MH- 50 ppm	8·7	78·65	87·35	1 : 9·04
,, 100 ,,	9·5	75·05	84·55	1 : 7·90
,, 150 ,,	11·2	79·75	90·95	1 : 7·12
,, 200 ,,	12·8	69·00	81·80	1 : 5·39
,, 250 ,,	13·2	66·27	79·47	1 : 5·02
IAA- 50 ,,	9·4	79·90	89·30	1 : 8·50
,, 100 ,,	10·0	77·60	87·60	1 : 7·76
,, 150 ,,	12·8	77·55	90·35	1 : 5·98
,, 200 ,,	12·3	78·23	90·53	1 : 6·36
,, 250 ,,	9·6	81·22	90·82	1 : 8·46
NAA- 50 ,,	13·0	68·38	81·38	1 : 5·26
,, 100 ,,	12·9	69·66	82·56	1 : 5·40
,, 150 ,,	11·7	65·17	76·87	1 : 5·57
,, 200 ,,	10·3	80·04	90·34	1 : 7·77
,, 250 ,,	9·6	79·40	89·00	1 : 8·27

C. D. at 5% level of probability.

(*i*)	For concentrations	0·67
(*ii*)	For treatments	0·52
(*iii*)	For treatments × concentrations	1·17
(*iv*)	For treatments *Vs* control	0·85

A perusal of this table reveals that in all the treatments there was an increase in the number of female flowers and suppression of male flowers over control. It was interesting to note that the ratio of female to male flowers in each treatment found superior to control, while the lowest female to male flower ratio was recorded in 250 ppm. MH followed by 50 ppm. NAA and 150 ppm. MH, but they were not significantly different from one another. Chaudhry and Pathak (2-4), also reported that MH (200 ppm) IAA (200 ppm) and NAA (100 ppm) significantly increased the number of female flowers and suppressed the number of male flowers. Ito and Saito (7-9) and Prasad and Tyagi (11) also reported similar response of plant growth regulators in *Cucumis sativus* L. and *Momordica charantia* L. respectively.

(ii) *Effect on Weight, size pollen fertility and soluble solids content*—Results of plant growth regulator spray on fruit weight, size, viability of pollen grains and soluble solids content were recorded and the data are summarized in table 2.

TABLE 2

Effect of various plant regulator sprays on the average weight, size, percentage of viable pollen and soluble solid content in Watermelon

Treatments	Average weight of fruits (Kg.)	Average size of fruits (cm.)		Percentage of viable pollen	Percentage of soluble solids
		Diameter	Length		
Control	4·74	87·7	98·3	92·61	11·6
MH– 50 ppm.	5·21	90·2	105·5	75·90	11·6
,, 100 ,,	5·56	90·5	108·0	76·34	11·8
,, 150 ,,	6·26	102·1	115·8	81·85	12·9
,, 200 ,,	9·50	123·4	139·2	85·00	13·6
,, 250 ,,	8·21	119·4	127·0	87·48	13·4
IAA– 50 ,,	4·57	87·6	93·4	82·30	11·6
,, 100 ,,	4·15	92·0	105·2	76·62	11·7
,, 150 ,,	4·82	100·7	115·6	85·10	11·8
,, 200 ,,	5·00	100·3	116·1	84·76	11·9
,, 250 ,,	4·94	98·5	110·4	82·03	11·9
NAA– 50 ,,	8·85	106·4	122·1	78·29	13·9
,, 100 ,,	11·33	132·2	147·4	86·36	13·6
,, 150 ,,	8·36	112·7	126·3	75·62	12·2
,, 200 ,,	5·52	97·5	113·0	74·76	12·8
,, 250 ,,	5·74	91·2	106·8	73·54	12·3

It is evident from this table that 100 ppm. NAA and 200 ppm. MH appreciably increased the weight and size of the fruits but the effect of IAA was not encouraging. Among the treatments the maximum fertile pollen grains (87·48%) were observed in 250 ppm. MH followed by 100 ppm. NAA (86·36%) and 150 ppm. IAA (85·10%) treatments. However, as high as 92·61 per cent fertile pollen grains were recorded in control. It is thus clear that the pollen grain fertility was reduced in all the treatments of plant regulators. Observations taken one and a half months after second spray showed that the fertility of pollen grain increased in lower concentrations as compared to high concentration (Table 2). Thus it may be presumed that the detrimental effect on the pollen fertility, caused by plant regulator treatments, decreased gradually. However, Chaudhary and Pathak (3) reported that the adverse effect on pollen grain fertility was more marked in the rainy season than in summer. Results of the present investigation are also in accordance with the observations of Chaudhary and Pathak (4) and Prasad and Tyagi (11) in case of Cucumber and Bitter gourd respectively. It is also clear that lower concentration of NAA (50 ppm) and higher concentration of MH (200 ppm) increased the soluble solids content.

SUMMARY

1. Studies were made on sex-expression, weight, size, and quality in watermelon, as affected by five concentrations (50, 100, 150, 200 and 250 ppm) of MH, IAA and NAA. -

2. All treatments decreased the female to male flower ratio, but the lowes female to male flower ratio was found with 250 ppm MH followed by 50 ppm. NAA and 150 ppm. M.H.

3. Considerable increase in fruit size and weight, over control was found in 100 ppm NAA and 200 ppm. M.H.

4. Pollen fertility was reduced in all the treatments of plant regulators while it was the maximum (92·61 per cent) in control plants.

5. Lower concentration of NAA (50 ppm) and higher concentration of MH ppm) increased soluble solids contents in watermelon.

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LITERATURE CITED

1. Brantley, B. B. & Warren, G. F. 1958. The effect of nitrogen, photoperiod and auxin on sex expression in the Musk-melon. *Plant Physiol.*, **33** (Suppl.), **XIX**.
2. Chaudhary, B. & Pathak, S. C. 1959 a. Sex expression and sex-ratio in cucmber (*Cucumis sativus* L.) as effected by plant regulator sprays. *Indian J. Hort.*, **16** (3) : 162-9.
3. Chaudhary B. & Pathak, S.C. 1959. b. Sex-expression and fruit development in cucumber (*Cucumis sativus* L.) as effected by gibberellin. *Indian J. Hort.* **16** (4) : 233-5.
4. Chaudhary, B. & Pathak S. C., 1960. Further studies on sex-expression and sex-ratio in cucumber (*Cucumis sativus* L.) as effected by plant regulator sprays. *Indian J. Hort.*, **17** (3-4): 210-6.
5. Chaudhary, R. S. 1957. Our concept regarding the possible significance of photo-period and hormones in Sex-expression and sex-reversal in plants. *Indian J. Hort*,. **14** (3) : 179-84.
6. Galun, E. 1959. Effects of gibberelic acid and naphthalene acetic acid on sex-expression and some morphological characters in the cucumber plant. *Phyton*, **13**: 1-8.
7. Ito, H, & Saito, T. 1956 a. Factors responsible for the sex-expression in Japanese cucumber, III. The role of auxin on plant growth and sex expression. *J. Hort. Ass.* Japan **25** : 101-310.

8. Ito H, and. Saito T. 1956. b. Factors responsible for sex expression in Japanese cucumber, IV. The role of auxin on plant growth and sex-expression. *J. Hort. Ass.* Japan **25** : 111-51.

9. Ito H, & Satio T. 1957. Factors responsible for sex expression in Japanese cucumber. VIII. The influence of long days and high temperature treatment of short duration at the seedling stage plus hormone spraying on the sex of flowers. *J. Hort. Ass.* Japan, **26** : 209-214.

10. Porter, D. R., Bisson, C. S. & Alliger, H. W. 1940. Factors affecting the total solids, reducing gugars, and succrose in water-melons. *Hilgardia* **13** : 31 66.

11. Prasad, A, & Tyagi, I. D. 1963. Effect of Maleic hydrazide on the sex-expression and sex-ratio in Bitter gourd (*Momordica charantia* L.) *Sci. and Cult.*, **29** : 205-6.

12. Prasad, A., Tyagi, I. D. & Dikshit, A. P. 1965. Preliminary studies on flowering, fruiting and quality in muskmelon (*Cucumis melo* L.) *Jour. Scient. Res. B.H.U.* **XVI** (1): 16-22.

13. Tiedjens, V.A. 1928. Sex-ratio in cucumber flowers as affected by different conditions of soil and light. *Jour. Agric. Res.*, **36**: 721-46.

14. Thakare, R. G. & Bora K. C. 1960. Influence of Neutron Rediation on sex-ratio in (*Citrulus vulgaris*. S.) *Curr. Sci.* **XXIX**: 322-23.

15. Whitaker, T. W. 1931. Sex-ratio and sex-expression in the cultivated cucurbits. *Amer. Jour. Bot.* **18** : 359-66.

USE OF DISTRIBUTION THEORY IN SOLVING EQUATIONS

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Abstract. This paper makes use of the properties of certain distributions to reduce the solution of algebraic equations and equations involving continuous functions to evaluating the limit of a definite integral which can be either obtained by explicit integration or by numerical integration using high speed digital computers.

Use of the distribution theory in solving differential and integral equations has now become a textbook work see for example (1) or (2). The purpose of this note is to extend the use to the equations of the type:

$$F(x)=0 \qquad \ldots(1)$$

given that there exist a and b such that $F(a)$ and $F(b)$ have opposite signs and F is continuous and monotonic in (a, b) possessing a continuous derivative in (a, b). By continuity and $F(a)$ and $F(b)$ having opposite signs clearly there exists an x_0 in (a, b) such that $F(x_0)=0$. To ensure uniqueness of the solution we require another condition:

$$F'(x)\neq 0 \text{ in } (a, b) \qquad \ldots(2)$$

Distributions (continuous linear functionals) are usually defined by their action on a class of elements for example infinitely differentiable functions with compact support. For our purpose we define a Dirac Distribution: $\delta(x)$ on $C^\circ(a, b)$ by its action on elements of $C^\circ(a, b)$ as follows:

$$<\delta(x), \phi(x)>=\phi(0) \text{ for all } \phi(x) \text{ in } C^\circ(a, b) \qquad .(3)$$

alternatively,

$$<\delta(x-x_0), \phi(x)>=\phi(x_0) \text{ for all in } C^\circ(a, b) \qquad \ldots(4)$$

$$=\int_a^b \delta(x-x_0)\, \phi(x)\, dx \quad \text{symbolically}$$

We shall denote the space of all distributions on $C^\circ(a, b)$ by $D[C^\circ(a, b)]$. Let $s_n(x)$ be a sequence of functions in $L^1(a, b)$ such that for all ϕ in $C^\circ(a, b)$:

$$\lim_{n\to\infty}\int_a^b s_n(x)\,\phi(x)\,dx=\phi(0) \text{ then we say that:}$$

$$s_n(x) \text{ converges weakly to } \delta(x). \qquad \ldots(5)$$

Examples of sequences converging to distributions on C_c^∞ can be easily constructed or found in several textbooks *e.g.*, (1) or (2). This weak convergence (in distributional sense) is appropriately defined depending upon the class on which our distributions are defined.

It can be verified that the following weekly converge in $D[C^\circ(a, b)]$ in the sense of definition given in (5) above:

(*i*) $s_n(x)=\dfrac{\sin nx}{x\pi}$

(*ii*) $s_n(x)=\dfrac{1}{\pi}\,\dfrac{n}{n^2+x^2}$

(*iii*) $s_n(x)=\dfrac{n}{\sqrt{\pi}}\,e^{-n^2x^2}$

Many more examples of this type can be easily constructed.

Since $F'(x)\neq 0$ in (a, b) it is clear that there exists

$$G=F^{-1} \qquad \dots(6)$$

such that:

$$x=G[F(x)]=F^{-1}[F(x)] \qquad \dots(7)$$

Since $F(a)$ and $F(b)$ have opposite signs, without any loss of generality we can assume that $F(a)$ is negative and $F(b)$ is positive. By uniqueness of the zero of F in (a, b) we have:

$$x_0=G[F(x_0)]=G(0) \qquad \dots(8)$$

since x_0 is the zero of F in (a, b).

Consider $[F(x)]$ distribution on $C^\circ[F(a), F(b)]$ and since $x=G[F(x)]$ is in $C^1[F(a), F(b)]$:

$$x\,[F'(x)]=G\,[F(x)],\ |F'(x)| \text{ is in } C^\circ[F(a), F(b)].$$

Clearly:

$$<\delta[F(x)], G[\{F(x)\}]\,|F'(x)|>=G(0)=G[F(x_0)]=x_0 \qquad \dots(9)$$

Thus if $s_n[F(x)]$ be any sequence in $C'[F(a), F(b)]$ converging weakly to $\delta[F(x)]$ in $D[C^\circ\{F(a), F(b)\}]$.

Clearly:

$$\lim_{n\to\infty}\left[\int_a^b s_n[F(x)]\,G[F(x)]\,|F'(x)|\,dx\right]=x_0 \qquad \dots(10)$$

We give below an example to illustrate this:

$F(x)=\cos x$ $\qquad a=0$ $\qquad b=\pi$

$s_n(x)=\dfrac{n}{\pi}\,\dfrac{1}{n^2+x^2}$

$s_n[F(x)]=\dfrac{n}{\pi}\,\dfrac{1}{n^2+\cos^2 x}$

$G[F(x)]=F^{-1}[F(x)]=x$

$F'(x)=-\sin x$ $\therefore$ $|F'(x)|$ in $(0, \pi)$ is $+\sin x$

Equation (10) with these substitutions gives:

$$x_0=\lim_{n\to\infty}\int_0^{\pi}\frac{n}{\pi}\,\frac{x\sin x}{n^2+\cos^2 x}\,dx$$

Substitution $x=\pi-y$ gives $dx=-dy$

$$\therefore\int_0^{\pi}\frac{n\,x\sin x}{\pi\,(n^2+\cos^2 x)}\,dx=\int_0^{\pi}\frac{n\,(\pi-y)\sin y}{\pi(n^2+\cos^2 y)}\,dy$$

$$\therefore\int_0^{\pi}\frac{nx\sin x}{\pi\,(n^2+\cos^2 x)}\,dx=\frac{n}{2\pi}\int_0^{\pi}\frac{\pi\sin y}{n^2+\cos^2 y}\,dy \quad \text{Put } \cos y=t$$

$$=\frac{n}{2}\left[\int_{-1}^{+1}\frac{dt}{n^2+t^2}\right]$$

$$=\frac{n}{2}\left[\frac{1}{n}\tan^{-1}\left(\frac{1}{n}\right)-\frac{1}{n}\tan^{-1}\left(-\frac{1}{n}\right)\right]$$

$$\therefore\ x_0=\lim\int_0^{\pi}\frac{n\,x\sin x}{\pi\,(n^2+\cos^2 x)}\,dx=\lim_{n\to\infty}\tfrac{1}{2}\left[\tan^{-1}\left(\frac{1}{n}\right)-\tan^{-1}\left(-\frac{1}{n}\right)\right]$$

$$=\tfrac{1}{2}\left[\frac{\pi}{2}--\frac{\pi}{2})\right]=\frac{\pi}{2}.$$

REFERENCES

1. Stakgold, I. 1967. *Boundry Value Problems of Mathematical Physics*, Vol. I and II, MacMillan.
2. Zemanian, A. H. 1965. *Dirtribution Theory and Transform Analysis*, McGraw Hill

STUDIES ON POLLEN ABORTION IN *CUCUMIS MELO* L.

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The abortion of pollen in a variety of male sterile plants has been assigned to the abnormal behaviour of tapetum (see Monosmoth, 1928; Artschwager, 1947; Singh and Hadley, 1961; Zenkteler, 1962; and Dubey and Singh, 1965). According to these workers, the tapetum fails to break down and leads to abortion of pollen for want of nutrition. Painter (1943) and Cooper (1952) have brought to light the role of tapetum in pollen development on biochemical basis. Chang (1954) has specifically mentioned that pollen abortion in maize is caused as a result of the insufficient supply of carbohydrates and other nutrients by persisting tapetum. Despite all these studies, the causes of male sterility are still shrouded in mystery. In order to understand the role that tapetum plays in pollen development, a comparative morphological, cytological and cytochemical studies were undertaken in male sterile and male fertile strains of *Cucumis melo* L.

Material and Methods

Seeds of male sterile and male fertile strains of *Cucumis melo* L. were so kindly provided to us by Dr. T. W. Whitaker of U.S.D.A. La Jolla, California. These were sown at the Botanic Gardens, R. B. S. College, Agra. Flower buds of the plants thus raised were fixed in formalin-acetic-alcohol, acetic-alcohol (1:3) and 80% Acetone for morphological, cytological and cytochemical studies respectively. Usual methods of dehydration, embedding and sectioning were followed. Heidenhan's iron-alum haematoxylin staining method was used for studying microsporogenesis. Localization of DNA was made by Feulgen's method used by Gomori (1952). Schiff's reagent was prepared after Longley's (1952) procedure. Enzyme acid phosphatase was localized by Jensen's (1956) method.

Observations

Anthers of both male fertile and male sterile plants are more or less of the same size at early stages of development. But, towards the completion of meiosis in microspore mother cells, increase in the size of anther of the fertile plants is far greater than in those of the sterile plants. Further, the anthers of male sterile plants are indehiscent and display abnormalities during microspore development. The details of microsporogenesis are described under separate heads, in the following pages.

Anther development and microsporogenesis in male fertile strain—Multicelled hypodermal archesporium differentiates in each lobe of the young anther. This divides to form the parietal layer and the sporogenous cells. The former produces by further divisions, endothecium, one or two middle layers and a single layer of tapetum. The primary sporogenous cells function directly as microspore mother cells (Fig. 1). Later these undergo meiosis and produce tetrahedral microspore tetrads (Fig. 2). The microspores develop a moderately thickened exine having characteristic reticulate sculpturing.

While the sporogenous cells are undergoing all these changes, the endothecial cells elongate radially and develop fibrous thickening (Fig. 4). The two middle layers persist till the formation of microspore tetrads (Fig. 2) but degenerate immediately after the microspore get separated from the common wall (Fig. 3). The tapetal cells are uninucleate in the beginning but become binucleate with age.

As the development of anther advances, the tapetal cells elongate radially and their nuclei show a considerable increase in diameter. But with the commencement of meiosis in microspore mother cells, the elongation of tapetal cells proceeds tangentially. This is also accompanied by a decrease in the nuclear size. The cell cytoplasm also show signs of degeneration. This degeneration of tapetal tissue continues even after the microspore tetrads have been formed (Fig. 2). By the time microspores get separated and each develops an intine and exine, the tapeal cells are left with only degenerated remains of cytoplasm and the nuclei (Fig. 3). The rounded microspores soon become converted into triangular, triporate and bicelled pollen grains. At the mature pollen grain stage tapetal degeneration is complete (Fig. 4).

Anther development and microsporogenesis in male sterile strain—The details of anther development in the male sterile plants of *Cucumis melo* L. are more or less, similar to those of the fertile plants. Thus, in order to avoid repetition, only such of the points have been described which distinguish the two strains.

Endothecial cells of the male sterile plants do not develop any fibrous thickenings (Figs. 6, 7) as they do in the fertile plants. Middle layers persist throughout the course of anther development (Fig. 9). The tapetal cells elongate radially during early stages and this elongation is, at no stage, replaced by tangential enlargement as is the case in male fertile plants. The growth of tapetal cells and their nuclei continues uninterrupted with the result that at the microspore stage, they become hypertrophied and subsequently occlude the anther cavity (Figs. 6, 7). This encroachment crushes the developing microspores (Figs. 7, 8). These encroaching tapetal cells are highly vacuolated, contain only a little of cytoplasm and abnormally enlarged nuclei. After the microspores get completely crushed the hypertrophied tapetal cells also degenerate (Fig. 9).

The microspore mother cells undergo a normal meiotic division and produce microspore tetrads (Fig. 5). The microspores constituting these tetrads fail to separate out and remain cemented together, forming irregular masses (Fig. 6). The microspores contain a little of cytoplasm and a degenerated nucleus. Their wall is not differentiated into exine and intine. As pointed out above, the invasion of tapetal cells on the anther sac, at the microspore stage, brings about a complete disorganization of the microspores. It is thus evident that the tapetal cells behave differently in the male sterile and male fertile strains. This is represented with the help of histograms (in Fig. 10).

Localization of enzyme acid phosphatase in the anthers of male sterile and male fertile strains—During the early stages of anther development enzymatic activity is equally low in both, the male fertile and male sterile plants. As the differentiation of wall layers proceeds, the concentration of the enzyme increase in plants of fertile strain. The enzymatic content increases considerably both in the tapetum and sporogenous tissue (Figs. 11, 12). As the microspore mother cells enter meiosis there is a further increase in the enzyme activity of tapetal cells. This reaches a peak at the time when microspore tetrads are formed (Figs. 13, 14). Microspores freed from the common wall also show a high concentration of enzyme acid phosphatase (Figs. 15, 16). At this stage the degenerated remains of tapetal cells display very poor enzyme activity. In these cells only a few black granules are noticeable along the walls. The mature pollen grains are exceedingly rich in phosphatase content, and therefore turn black or dark brown. In this state it is easy to tell apart the viable and non-viable pollen grains, the latter staining only feebly. Thus, it is evident that acid phosphatase activity in the tapetal cells of the fertile plants of *Cucumis melo* L. shows a gradual increase till the development of microspore tetrads. But as the microspores separate, the activity of the enzyme in the tapetum decreases, till the cells finally degenerate.

The anthers of the male sterile plants do not display any significant increase in the acid phosphatase content, even as the anther development advances and the wall layers differentiate out. The cells of wall layers including the tapetum are poor in enzyme content (Figs. 17,18). The same also holds true for the microspore mother cells. Even after the pollen mother cells have entered meiosis and microspore tetrads are formed the acid phosphatase activity does not accelerate (Figs. 19, 20). This is in sharp contrast to the state of affairs in the male fertile plants. Microspores which fail to separate out from the common wall also show poor enzyme content (Fig. 21). Tapetal cells at this stage become abnormally enlarged but are found to be deficient in acid phosphatase (Fig. 22).

Localization of Desoxyribose nucleic acid in the anthers of male fertile and male sterile strains—At pre-meiotic stages of anther development the distribution of DNA is more or less similar in anthers of both the strains. The nuclei of archesporial initial cells are strongly feulgen positive. After the periclinal division of these cells, the concentration of feulgen positive substance remains the same in the nuclei of primary parietal cells and primary sporogenous cells. The tapetal cells as also the microspore mother cells, possess darkly stained nuclei (Fig. 23). Apart from the nucleus, the cytoplasm of microspore mother cells also gets feebly stained. This can be explained on the basis of Sparrow and Hammond's

(1947) findings in a number of plants. They report that the feulgen positive substance in microspore mother cells is lost from nuclei into cytoplasm. With the formation of microspore tetrads the nuclei of tapetal cells stain very feebly in the male fertile plants (Fig. 24). This nucleus enters degeneration soon after and by the time, microspores are freed, the nuclei are lost. At this stage the microspore nuclei are transiently stained (Fig. 25). Thus, it is evident, the concentration of feulgen positive substance in the tapetal nuclei of male fertile plants is maximum at the microspore mother cell stage. With the formation of microspore tetrads, the concentration decreases, till the nuclei are finally lost.

In the anthers of male sterile plants the tapetal nuclei do not display any change in the concentration of feulgen positive substance, even when the microspore tetrads have been formed (Fig. 26). It is curious to see the tapetal nuclei darkly stained even at this stage. The cells of the microspore tetrads on the contrary possess poor feulgen positive substance in their nuclei. With the development of microspores, however, the concentration of the feulgen positive substance decreases in tapetal nuclei (Fig. 27). Instead the walls of microspores put up a high feulgen positive reaction. When the tapetal cells are at the peak of development, their nuclei stain rather poorly, indicating the presence of only traces of DNA positive substance (Fig. 28). The degenerated mass of microspores, surprisingly, bears a large amount of feulgen positive substance.

DISCUSSION

The role of tapetum in causing male sterility has been described in crop plants of diverse phylogenetic position, e.g., sugarbeets (Artschwager, 1947); *Sorghum* (Singh and Hadley, 1961); squash (Singh and Rhodes, 1961); carrots (Zenkteler, 1962); and linseed (Dubey and Singh, 1965). A critical survey of the literature reveals that the behaviour of tapetum in causing pollen abortion varies from one plant to the other. In *Sorghum*, Singh and Hadley (1961) have attributed male sterility to the persisting nature of tapetum. In male sterile carrots, Zenkteler (1962) reports that complete microspore abortion is a result of periplasmodium formation. The observations of Dubey and Singh (1965) on linseed prove that abortion of microspores is either caused by the persistence of tapetal cells or by the formation of tapetal periplasmodium. The fact that the behaviour of tapetum is vital for pollen development has been proved variously in this laboratory. Apart from studying the nature of tapetum in naturally occurring male sterile plants, data is also being collected on male sterile plants produced through the use of gametocides. Preliminary studies conducted on male sterile plants of *Cajanus cajan* and *Phaseolus radiatus* through the use of F. W. 450 have revealed, that the pollen abortion is, beyond doubt caused by the persistence of tapetum (Koul, unpublished).

The persistence of tapetum beyond a certain stage seems deleterious for the normal growth and development of the pollen grains. This is because the developing microspores bank upon tapetum for food supply. This is brought out by the fact that in male fertile counterparts the gradual degeneration of tapetum advances the growth of microspores.

The present material of male sterile *Cucumis melo* L. represents a leap forward with regard to the behaviour of tapetum. Because, in this case, the tapetal cells not only remain intact, as in Sorghum (Singh and Hadley, 1961); carrots (Zenkteler, 1962); and linseed (Dubey and Singh, 1965), but also grow considerably in size and become hypertrophied, subsequently invading the anther-sac cavity. This encroachment crushes the microspores with the result that they degenerate. Artschwager (1947) and Monosmith (1928) have made almost similar observations in semi-male sterile sugarbeets and onion respectively. The cause of this inflammation is, however, not well understood. One can conceive of two possible reasons. The first, that the tapetum receives more food material from outer tissues than it is capable of supplying to the developing microspores, probably because of its persistent wall etc. The second, that the tapetal cells receive little or no food material from elsewhere and therefore take to haustorial activity in search of nutrition. The intensity of vacuolation and the presence of only a small amount of cytoplasm in these cells are evidences, suggestive of a low metabolic activity. Obviously, the tapetum of male sterile plants receives very little food material from outer parts of the plant. The hypertrophying in all probability is therefore, for want of food material. The increase towards the anther cavity may well be because in this direction they are faced with minimum resistance. The final degeneration of tapetal cells is obviously because of the non-availability of food material. Since the tapetum fails to nourish the microspores degenerate out of starvation resulting in complete male sterility.

From the foregoing description regarding the localization of acid phosphatase activity it follows that in anthers of fertile plants the increase in enzyme activity is in line with the advancement of development, but in male sterile plants it is not so. Further, the tapetum, which is regarded as the source of food material for the developing sporogenous tissue seems devoid of enzyme activity in sterile anthers. This points to the low metabolic activity in these cells and supports our earlier suggestion regarding the problem of hypertrophying of tapetal cells. The activity is found to be higher in areas of greater metabolic activity, rapid cellular differentiation, protoplasmic synthesis and vascularization (Van Fleet, 1952; Wilson and Cutter, 1952, 1955; Wilson 1949 Koul, unpublished).

The present finding on localization of enzyme acid phosphatase is also supported by those of Singh (1961) on *Antirrhinum Orontium* Linn. According to him the activity of enzyme acid phosphatase appears to be associated with the development of microspores and their differentiation into viable pollen grains.

On the basis of the distribution pattern of DNA within different wall layers of an anther, Cooper (1952) demonstrated the transfer of DNA from tapetal cells to the developing microspore mother cells. This has been turned down by Taylor and McMaster (1954) on the basis of autoradiographic studies. The tapetal nuclei labelled with P 32 did not transfer the labelled DNA to the microspore mother cells. Takates (1962) has however, detected the utilization of DNA break down products of the tapetal cells during DNA synthesis in the microspores of *Lilium longiforum*. According to him the tapetal cells on degeneration constitute the source of precursor material for DNA synthesis in the microspores. On the basis of autoradiographs he has concluded that the label H3 from tapetal nucleus was lost shortly before DNA synthesis in the microspores. The microspore wall were transiently labelled, but the microspore nuclei did not incorporate a detectable amount of the label.

The present observation on the distribution of feulgen positive substance in the anthers of male fertile and male sterile strains of *Cucumis melo* L. clearly demonstrates transfer of feulgen positive substance from the tapetal cells to the developing microspores. In the anthers of both the strains tapetal nuclei show a high concentration of feulgen positive substance at microspore mother cell stage. Later, when the microspore mother cells enter meiosis, the concentration of feulgen positive substance of tapetal nuclei decreases in the anthers of fertile line, indicating the transfer of feulgen positive substance from tapetum to the sporogenous tissue. On the other hand the anthers of sterile strains do not show any change in the concentration of feulgen positive substance even upto the formation of microspore tetrads. But on the formation of microspores which do not separate out from one another, the tapetal nuclei show decrease in the concentration of feulgen positive substance. Thus the transfer of feulgen positive substance from the tapetal nuclei to microspore mother cells do not take place in male sterile plants, but rather too late. This delay seems to lead to the formation of non-viable microspores. The feulgen positive substance moving from the tapetum to the microspore mother cells may either be DNA itself or DNA precursor as suggested by Takates (1962).

SUMMARY

In order to work out the causes of male sterility in *Cucumis melo* L., development of anther, the pattern of distribution of enzyme acid phosphatase and DNA were studied in the male fertile and male sterile strains. The structure of anther and the details of meiosis are similar in both the strains. The tapetum, which constitutes the innermost wall layer of the anther, however, behaves differently. In male fertile plants the tapetum degenerates as the microspore development advances, while in the male sterile plants the tapetal cells persist, become hypertrophied and encroach upon anther sac cavity. The persistence of the tapetal cells results in the starvation of developing microspores, for want of nutrition. These starved microspores are subsequently crushed by the mechanical pressure exerted by the hypertrophied tapetal cells.

The enzymatic activity of the tapetum increases upto formation of microspore tetrads in male fertile plants. Thereafter the activity decreases, till the tapetum is finally lost. In male sterile plants, on the contrary, the tapetum at

no stage possesses significant amount of the enzyme. The lack of enzyme has been correlated with low metabolic activity of tapetum, which constitutes the main cause of male sterility.

The studies of DNA distribution support earlier suggestion of the transfer of DNA or DNA precursors from the tapetum to the developing microspores. Delay in the transfer of this substance in male sterile plants seems to constitute another cause of pollen abortion.

LITERATURE CITED

1. Artschwager, E. 1947. Pollen degeneration in male sterile sugarbeets, with special reference to the tapetal plasmodium. *J. Agri. Res.*, **75**: 191- 97.
2. Chang, T. T. 1954. Pollen sterility in maize. M. S. thesis Conrell University.
3. Cooper, D. C. 1952. The transfer of DRNA from the tapetum to the microsporocytes at onset meiosis, *Amer. Nat.*, **86** : 219–229.
4. Dubey, D. K. & Singh, S. P. 1965. Mechanism of pollen abortion in three male sterile lines of flax (*Linum usitotissimum* L.). *Crop. Sci.*, **5**: 121-124.
5. Gomori, G. 1952. Microscopic histochemistry, Principles and practice. University of Chicago Press, Chicago.
6. Jensen, W. A. 1956. The cytochemical localization of acid phosphatase in root tip cells. *Amer. J. Bot.*, **43** : 50-54.
7. Longley, J. B. 1952. Effectiveness of Schiff variants in the periodic-schiff and feulgen nuclear technic. *Stain Technol.*, **27** : 161-169.
8. Monosmith, H. H. 1928. Male sterility in *Allium cepa* L. Ph. D. thesis, University of California.
9. Painter, T. S. 1943. Cell growth and nucleic acid in pollen of *Rhoeo discolor. Bot. Gaz.* **105** : 58-68.
10. Singh, S. P. 1961. Localization of acid phosphatase in the anthers of *Antirrhinum orontium* Linn. *Agra Univ. J. Res.* (*Sci.*), **10** (II) : 103-104.
11. Singh, S. P. & Hadley, H. H. 1962. Pollen abortion in cytoplasmic male sterile *Sorghum*. *Crop. Sci.*, **1** : 430–432.
12. Singh, S. P. & Rhodes, A. M. 1961. A morphological and cytological study of male sterility in *Cucurbita maxima*. *Proc. Amer. Soc. Hort. Sci.*, **78** : 375 378.
13. Sparrow, A. H. & Hammond, M. R. 1947. Cytological evidence for the transfer of DNA from nucleus to cytoplasm in certain plant cells. *Amer. J. Bot.*, **34** : 439-445.
14. Takates, S. T. 1962. An attempt to detact utilization of DNA break down products from the tapetum for DNA synthesis in the microspore of *Lilium longiforum*. *Amer J. Bot.*, **7** : 748-778.
15. Taylor, J H. & McMaster, R. D. 1954. Autoradiographic and microsphotometric studies of DNA during microgametogenesis in *Lilium longiforum*. *Chromosoma* **6** : 487-521.
16. Van Fleet, D. S. 1952. Histochemical localization of acid phosphatase in vascular plants. *Bot. Rev.*, **18** : 354-398.
17. Wilson, K. S. 1949. Histochemical localization of acid phosphatase during the development of cucurbit fruits. *Amer. J. Bot.*, **36** : 806-807.
18. Wilson, K. S. & Cutter, V. M. 1952. The distribution of acid phosphatase during development of fruit of *Cocos nucifera*. *Amer. J. Bot.*, **39** : 57-58.
19. Wilson, K. S. & Cutter, V. M. 1955. Localization of acid phosphatase in the embryo sac and endosperm of *Cocos nucifera*. *Amer. J. Bot.*, **42**: 116-119.
20. Zenkteler, M. 1962. Microsporogenesis and tapetal development in normal and male sterile carrots (*Daucus carota*). *Amer. J. Bot.*, **49**: 341-348.

EXPLANATION TO THE PLATE I

Figs. 1-9. Photomicrographs showing microsporogenesis in male sterile and male fertile strains *Cucumis melo* L. Fig. 1. Part of t.s. fertile anther showing microspore mother cell X 500. Fig. 2. Same showing microspore tetrads. X 500. Fig. 3. Part of t.s. fertile anther showing young pollen grains. X 410. Fig. 4. Same at mature pollen grain stage. X 410. Fig. 5. Part of t. s. sterile anther to show tetrads. Tapetal layer is intact. X 500. Fig. 6. Same showing non-viable microspores cemented in tetrads and hypertrophied tapetal cells. X 410. Fig. 7. Same to show complete degeneration of microspores. Note abnormal invasion of tapetal cells and their nuclei. X 410. Fig. 8. Same in l.s. X 410. Fig. 9. Part of t. s. sterile anther to show complete degeneration of tapetum and sporogenous tissue. X 410.

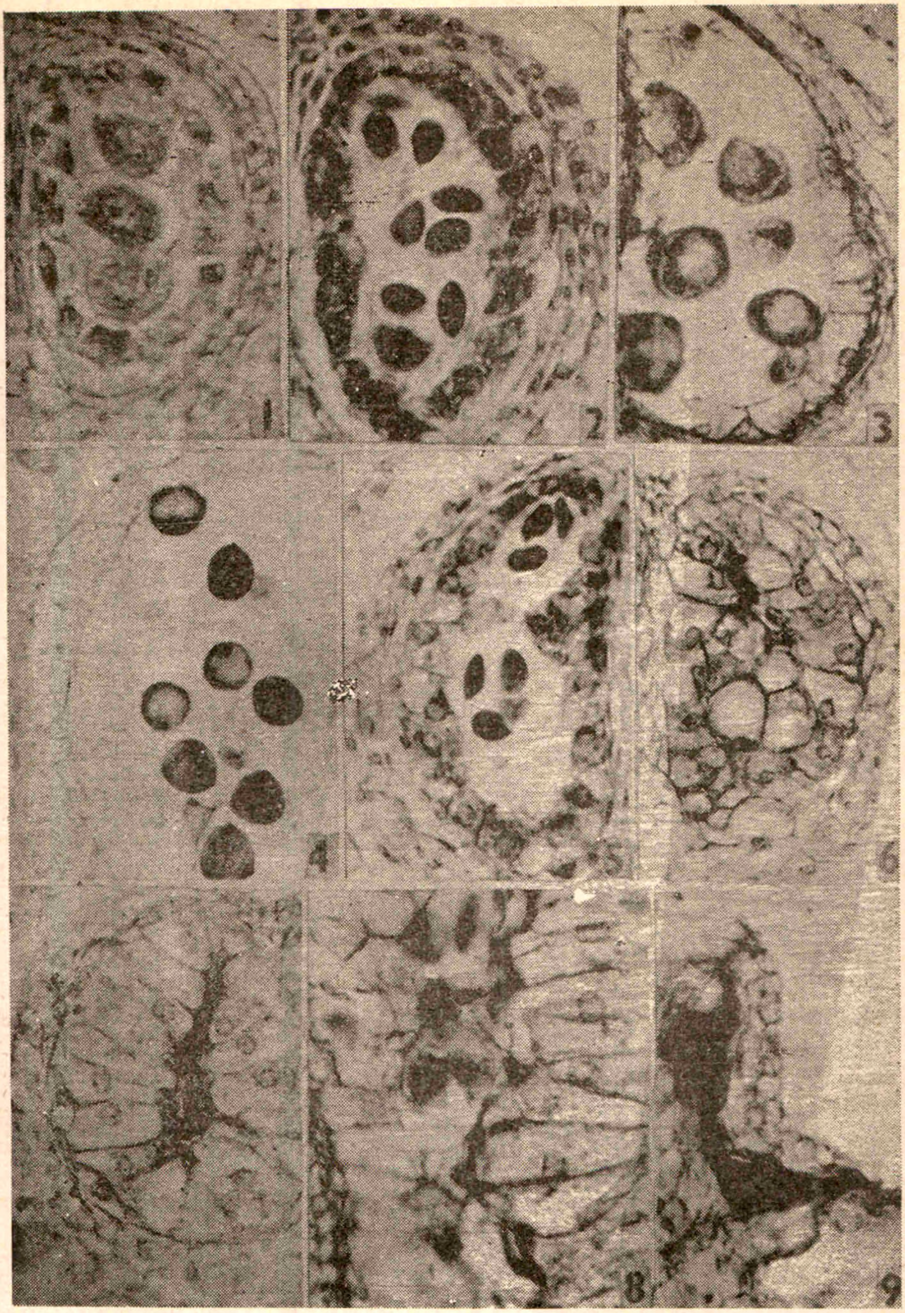
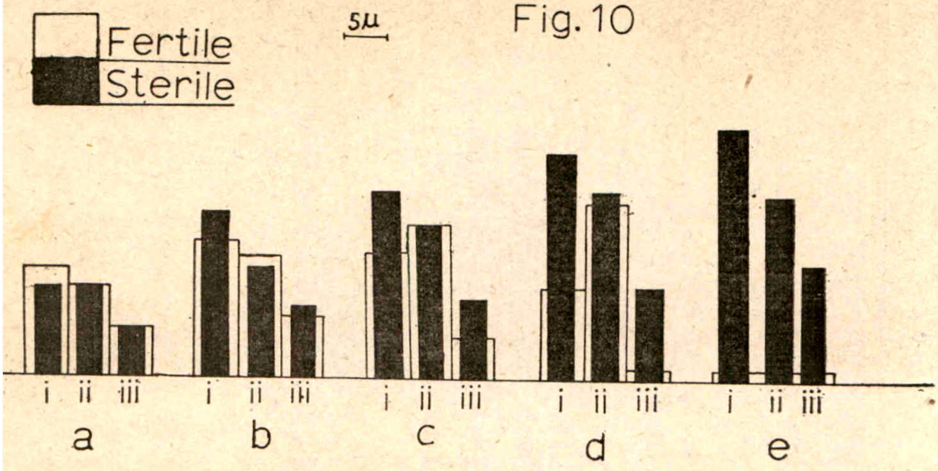


Plate I



Explanation to the Figure 10

Fig. 10. Histograms showing the comparative increase and decrease in the (i) length,) width of tapetal cells and (iii) diameter of tapetal nuclei at different stages of anther velopment in both the strains. (a) Sporogenous cell stage, (b) Microspore mother cell ge, (c) Tetrads stage, (d) Microspores, and (e) Pollen grains stage.

Explanation to the Plate II

Figs. 11-12. Photomicrographs showing localization of enzyme acid phosphatase in the thers of male fertile and male sterile strains of *Cucumis melo* L.

Fig. 11. Part of t. s. fertile anther showing microspore mother cells. Note enzymatic ivity in the microspore mother cells. X 500. Fig. 12. Control. X 500. Fig. 13. me showing microspore tetrads. Note the concentration of enzyme in the tapetal cells l tetrads. X 500. Fig. 14. Control X 500. Fig. 15. Same showing mature pollen ins. Note the enzyme concentration in pollen grains. X 200. Fig. 16. Control. 200. Fig. 17. Part of t. s. sterile anther showing microspore mother cells. Note or enzymatic contents in tapetal cells and microspore mother cells. X 500. Fig. 18. ntrol X 500. Fig. 19. Same showing microspore tetrads. Note the enzyme deficiency the tapetal cells and microspore tetrads. X 500. Fig. 20. Control X 500. Fig. 21. me showing microspores and tapetal cells. Note the absence of enzyme in the tapetal ls and microspores. X 500. Fig. 22. Same showing complete degeneration of crospores. Note the tapetal cells which are devoid of enzyme activity. X 500.

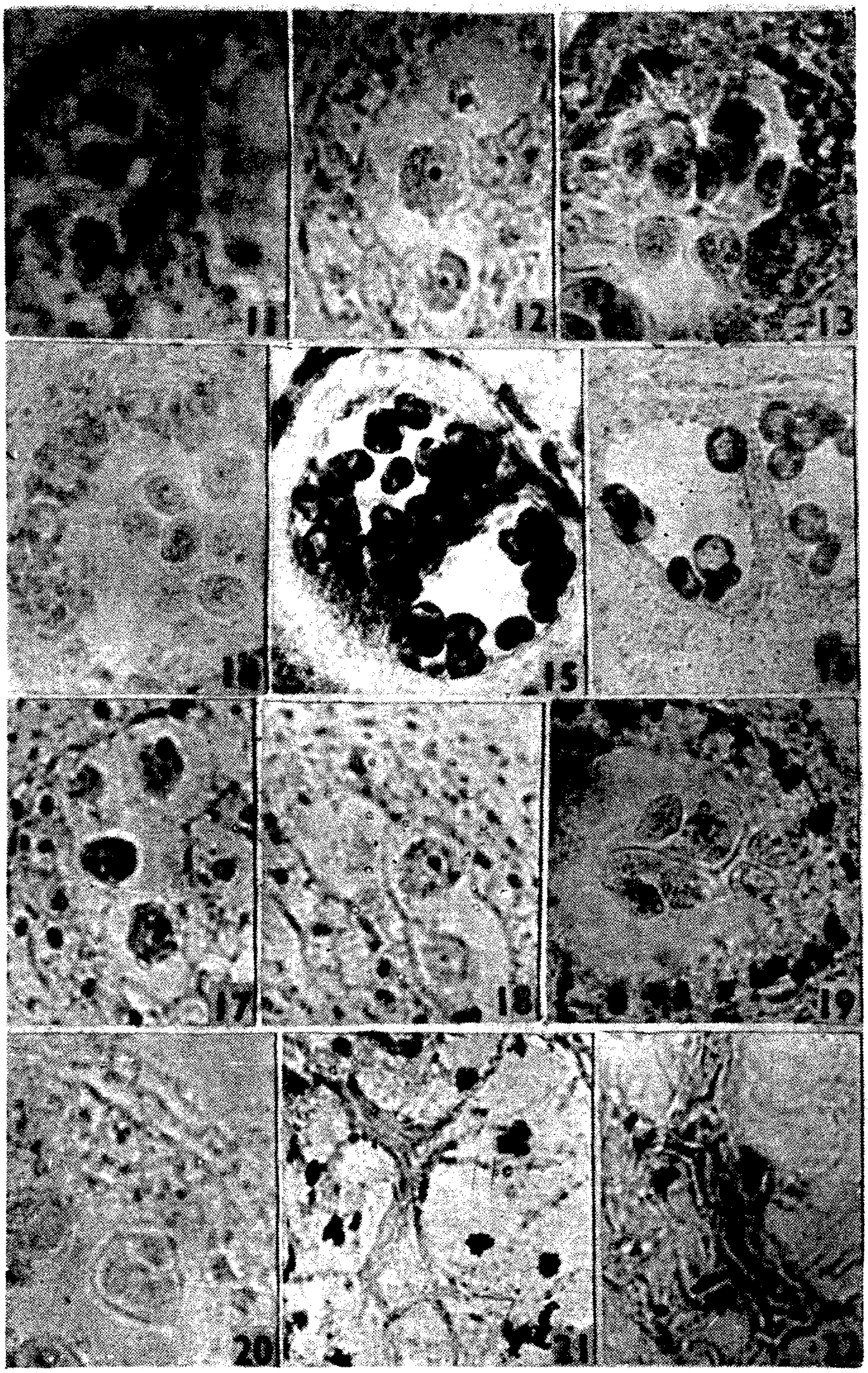
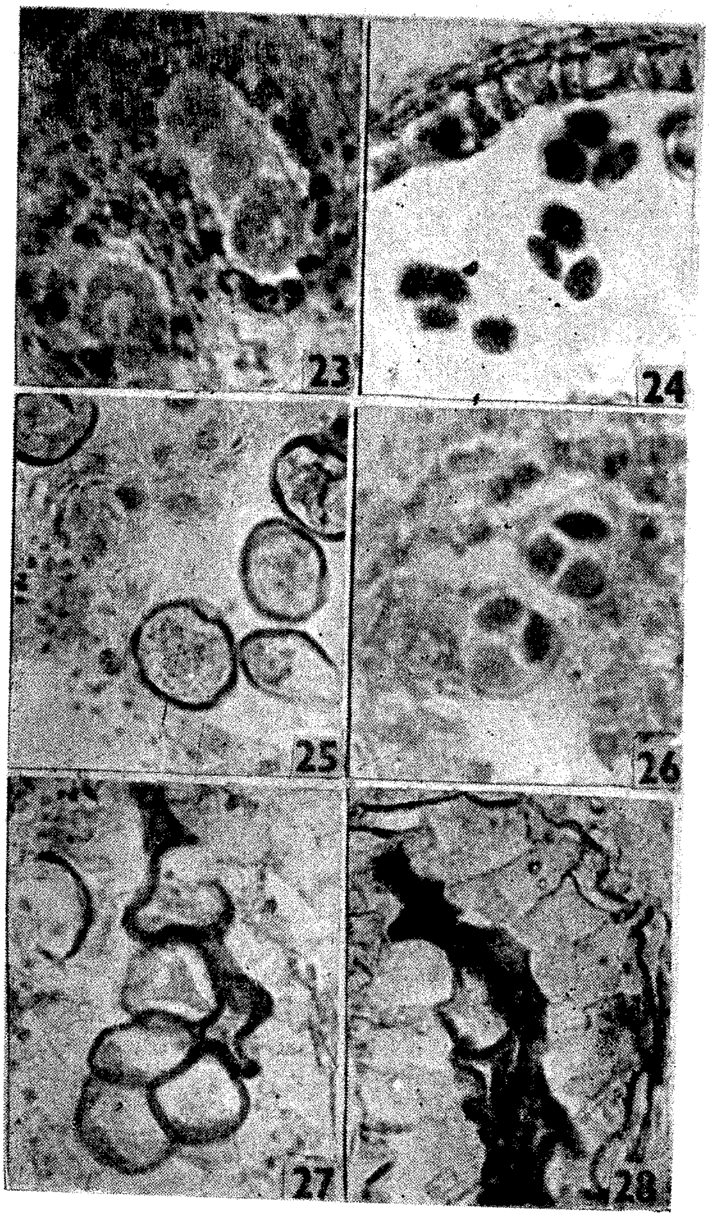


Plate II



EXPLANATION TO THE PLATE III

Figs. 23-28. Photomicrographs showing localization of DNA in the anther of male fertile and male sterile strains of *Cucumis melo* L. Fig. 23. Part of t.s. fertile anther showing microspore mother cells. Note darkly stained tapetal nuclei. X 500. Fig. 24. Same showing microspore tetrads. Note the darkly stained tetrads and poorly stained tapetal cells. X 500. Fig. 25. Same showing mature microspores. X 500. Fig. 26 Part of t.s. sterile anther showing microspore tetrads. X 500. Fig. 27. Same showing microspore cemented in tetrads. Note the darkly stained microspore walls and poorly feulgen positive tapetal cells. X 500. Fig. 28. Same showing complete degeneration of microspores. Note the darkly stained degenerated microspores and absence of feulgen positive substance from the tapetal cells. X 500.

FLOW THROUGH AN ANNULAR CHANNEL OF A PARTICULAR TYPE

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SUMMARY

In this paper, the steady flow of a liquid through a long annular, channel, has been considered. The section of the channel is bounded by two confocal ellipses. Both the walls of the channel are moving with uniform velocities in the direction of the axis of the channel.

INTRODUCTION

Steady flow of a liquid through a channel with an annular section formed of two concentric circles has been discussed in Ramsay[1]. Here, we shall consider the flow of a liquid through a channel whose walls are moving with uniform velocities. The section of the channel is bounded by two confocal ellipses.

Let the z-axis be taken along the axis of the channel, and w be the velocity in this direction, the other components of the velocity being assumed to be zero. Then, by reference to the equation of continuity $\frac{\partial w}{\partial z}$ must be zero, so that w is a function of x and y only.

The equation of motion for steady flow reduces to

$$\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}\right)=\frac{\partial p}{\partial z}$$

where $\frac{\partial p}{\partial z}$ is a constant.

Denoting this by $-P$, the velocity w has to satisfy the equation

$$\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}=-\frac{P}{\mu} \qquad ..(1)$$

Let the equation of the confocal ellipses be

$$\frac{x^2}{a^2-\alpha^2}+\frac{y^2}{b^2-\alpha^2}=1 \qquad ..(2)$$

And,

$$\frac{x^2}{a^2-\beta^2}+\frac{y^2}{b^2-\beta^2}=1,\ \alpha<\beta \qquad ..(3)$$

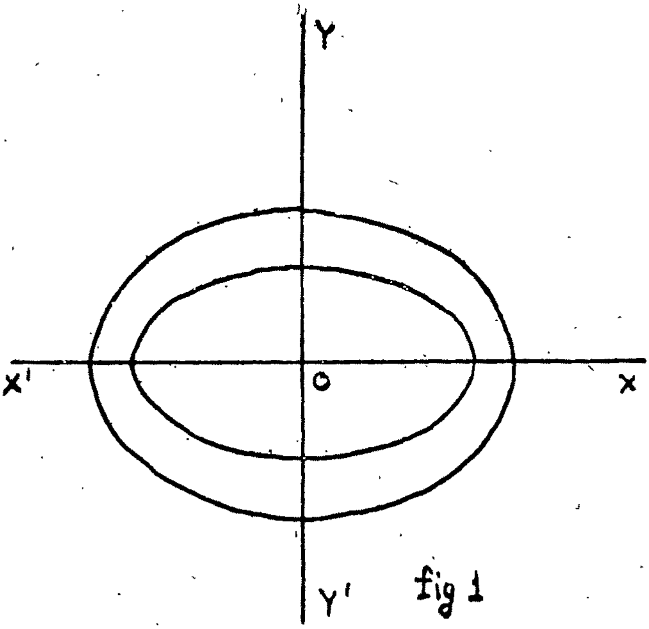

fig 1

TRANSFORMATION OF COORDINATES

put $x+iy=c\cosh\ (\xi+i\eta)$ ..(4)

Then, $\xi=$constant represents confocal ellipse

$$\frac{x^2}{c^2\cosh^2\xi}+\frac{y^2}{c^2\sinh^2\xi}=1$$

And, $\eta=$constant represents a confocal hyperbola

$$\frac{x^2}{c^2\cos^2\eta}-\frac{y^2}{c^2\sin^2\eta}=1$$

Therefore, from equations (2) and (3)

$$a^2-\alpha^2=c^2\cosh^2\xi_1,\ b^2-\alpha^2=c^2\sinh^2\xi_1$$

$$\text{and}\quad b^2-\beta^2=c^2\cosh^2\xi_2,\ b^2-\beta^2=c^2\sinh^2\xi_2$$

from which the values of ξ_1, ξ_2 and C can be calculated.

From (4) the equation of motion (1) transforms to

$$\frac{\partial^2 w}{\partial\xi^2}+\frac{\partial^2 w}{\partial\eta^2}=-\frac{P}{2\mu}(\cosh 2\xi-\cos 2\,\eta) \qquad ..(5)$$

Subject to the conditions

$$\begin{aligned}
&w=w_1 \ \text{when}\ \xi=\xi_1,\ 0\leqslant\eta\leqslant 2\pi\\
&w=w_2 \quad ,, \quad \xi=\xi_2, \quad ,,\\
&\frac{\partial w}{\partial\eta}=0 \quad ,, \quad \eta=0,\ \ \xi_2\leqslant\xi\leqslant\xi_1\\
&\frac{\partial w}{\partial\eta}=0 \quad ,, \quad \eta=\frac{\pi}{2} \quad ,,
\end{aligned}$$

SOLUTION OF THE EQUATION OF MOTION

putting $\theta=2\eta$

The equation (5) becomes

$$\frac{\partial^2 w}{\partial\xi^2}+4\frac{\partial^2 w}{\partial\theta^2}=-\frac{P}{2\mu}(\cosh 2\,\xi-\cos\theta) \qquad ..(6)$$

Subject to the conditions

$$\begin{aligned}
&w=w_1,\ \text{when}\ \xi=\xi_1,\ 0\leqslant\theta\leqslant\pi\\
&w=w_2, \quad ,, \quad \xi=\xi_2, \quad ,,\\
&\frac{\partial w}{\partial\theta}=0\ , \quad ,, \quad \theta=0\ ,\ \xi_2\leqslant\xi\leqslant\xi_1\\
&\frac{\partial w}{\partial\theta}=0\ , \quad ,, \quad \theta=\pi\ ,\ \xi_2\leqslant\xi\leqslant\xi_1
\end{aligned}$$

Let us use Fourier's Cosine Transform

$$\overline{w}=\int_0^{\pi} w\cos p\theta\, d\theta, \ \text{(where } p \text{ is zero or any other positive integer)}$$

Then, from Tranter[2]

$$\int_0^{\pi} \frac{\partial^2 w}{\partial \theta^2} \cos p\theta \, d\theta = (-1)^p \left(\frac{\partial w}{\partial \theta}\right)_{\pi} - \left(\frac{\partial w}{\partial \theta}\right)_0 - p^2 \bar{w}$$

$$= -p^2 \bar{w}, \left(\text{since } \left(\frac{\partial w}{\partial \theta}\right)_0 = \left(\frac{\partial w}{\partial \theta}\right)_{\pi} = 0 \right)$$

Also, $\int_0^{\pi} \cos p\theta \, d\theta = \pi$, when $p=0$

And, $\int_0^{\pi} \cos p\theta \, d\theta = 0$, when $p=1$ or any other integer

Again, $\int_0^{\pi} \cos p\theta \cos \theta \, d\theta = \frac{\pi}{2}$, when $p=1$

And, $\int_0^{\pi} \cos p\theta \cos \theta \, d\theta = 0$, when $p \neq 1$

Applying the transform to the equation (6) we have

$$\frac{\partial^2 \bar{w}}{\partial \xi^2} = -\frac{P\pi}{2\mu} \cosh 2\xi \quad , \text{ when } p=0 \qquad \ldots(7a)$$

$$\frac{\partial^2 \bar{w}}{\partial \xi^2} - 4\bar{w} = \frac{P\pi}{4\mu} \quad , \text{ when } p=1 \qquad \ldots(7b)$$

And, $$\frac{\partial^2 \bar{w}}{\partial \xi^2} = 4 p^2 \bar{w} \quad , \text{ when } p \text{ is any integer.} \qquad \ldots(7c)$$

The solution of (7a) is

$$\bar{w} = A + B\xi - \frac{P\pi}{8\mu} \cosh 2\xi \qquad \ldots(8a)$$

Subject to the conditions

$\bar{w} = w_1 \pi$, when $\xi = \xi_1$

And $\bar{w} = w_2 \pi$, when $\xi = \xi_2$

Which gives

$$\bar{w} = \frac{\pi}{\xi_1 - \xi_2} \{ (w_2 \xi_1 - w_1 \xi_2) + (w_1 - w_2)\xi \} + \frac{P\pi}{8\mu} \left\{ \frac{\xi_1 \cosh 2\xi_2 - \xi_2 \cosh 2\xi_1}{\xi_1 - \xi_2} + \frac{\cosh 2\xi_1 - \cosh 2\xi_2}{\xi_1 - \xi_2} \xi - \cosh 2\xi \right\} \qquad \ldots(8b)$$

The solution of (7b) is

$$\bar{w} = c_1 e^{2\xi} + D_1 e^{-2\xi} - \frac{P\pi}{16\mu} \qquad \ldots(8c)$$

Subject to the conditions

$\bar{w} = 0$, when $\xi = \xi_1$

$\bar{w} = 0$, when $\xi = \xi_2$

Therefore, $$\bar{w} = \frac{P\pi}{16\mu} \left\{ \frac{e^{2\xi} + e^{2(\xi_1 + \xi_2 - \xi)}}{e^{2\xi_1} + e^{2\xi_2}} - 1 \right\} \qquad \ldots(9a)$$

And the solution of (7c) is

$$\bar{w} = c\, e^{2p\xi} + D e^{-2p\xi} \qquad \text{..(9b)}$$

Subject to the conditions

$$\bar{w} = 0\ , \quad \text{when } \xi = \xi_1$$

$$\bar{w} = 0\ , \quad \text{when } \xi = \xi_2$$

which gives, $\bar{w} = 0$ ..(9c)

From Tranter[3], the inversion formula

$$w = \frac{1}{\pi}(\bar{w})_{p=0} + \frac{2}{\pi}\sum_{p=1}^{\infty} \bar{w} \cos p\theta$$

gives

$$\bar{w} = \left[\frac{P}{8\mu}\left(\frac{\cosh 2\xi_1 - \cosh 2\xi_2}{\xi_1 - \xi_2}\,\xi + \frac{\xi_1 \cosh 2\xi_2 - \xi_2 \cosh 2\xi_1}{\xi_1 - \xi_2} - \cosh 2\xi\right) + \frac{w_2\,\xi_1 - w_1\,\xi_2 + (w_1 - w_2)\xi}{\xi_1 - \xi_2}\right] + \frac{P}{8\mu}\left(\frac{e^{2\xi} + e^{2(\xi_1 + \xi_2 - \xi)}}{e^{2\xi_1} + e^{2\xi_2}} - 1\right)\cos 2\eta \qquad \text{..(10)}$$

Particular Cases

(I) When the outer wall is stationary and the inner is moving with velocity w_2, putting $w_1 = 0$, we have

$$w = \left[\frac{P}{8\mu}\left(\frac{\cosh 2\xi_1 - \cosh 2\xi_2}{\xi_1 - \xi_2}\,\xi + \frac{\xi_1 \cosh 2\xi_2 - \xi_2 \cosh 2\xi_1}{\xi_1 - \xi_2} - \cosh 2\xi\right) + \frac{w_2(\xi_1 - \xi)}{\xi_1 - \xi_2}\right] + \frac{P}{8\mu}\left(\frac{e^{2\xi} + e^{2(\xi_1 + \xi_2 - \xi)}}{e^{2\xi_1} + e^{2\xi_2}} - 1\right)\cos 2\eta \qquad \text{..(11)}$$

(II) When both walls are stationary, that is, $w_2 = w_1 = 0$ we have,

$$w = \frac{P}{8\mu}\left[\left(\frac{\cosh 2\xi_1 - \cosh 2\xi_2}{\xi_1 - \xi_2}\,\xi + \frac{\xi_1 \cosh 2\xi_2 - \xi_2 \cosh 2\xi_1}{\xi_1 - \xi_2} - \cosh 2\xi\right) + \left(\frac{e^{2\xi} + e^{2(\xi_1 + \xi_2 - \xi)}}{e^{2\xi_1} + e^{2\xi_2}} - 1\right)\cos 2\eta\right] \qquad \text{..(12)}$$

(III) When outer wall moves with velocity w_1 and the inner is stationary i.e., $w_2 = 0$

Then,

$$w = \left[\frac{P}{8\mu}\left(\frac{\cosh 2\xi_1 - \cosh 2\xi_2}{\xi_1 - \xi_2}\,\xi + \frac{\xi_1 \cosh 2\xi_2 - \xi_2 \cosh 2\xi_1}{\xi_1 - \xi_2} - \cosh 2\xi\right) + \frac{(\xi - \xi_2)}{\xi_1 - \xi_2}w_1\right] + \frac{P}{8\mu}\left(\frac{e^{2\xi} + e^{2(\xi_1 + \xi_2 - \xi)}}{e^{2\xi_1} + e^{2\xi_2}} - 1\right)\cos 2\eta \qquad \text{..(13)}$$

(IV). When $\xi_2 = 0$ the inner wall becomes an infinite plane whose breadth extends from one focus to the second focus. If this plane as well as outer wall moves with velocities w_2 and w_1 respectively.

Then,

$$w=\left[\frac{\mathrm{P}}{8\mu}\left(\frac{\cosh 2\xi_1-1}{\xi_1}\xi+1-\cosh 2\xi\right)+\frac{w_2\xi_1+\xi\,(w_1-w_2)}{\xi_1}\right]$$

$$\frac{\mathrm{P}}{8\mu}\left(\frac{e^{2\xi}+e^{2(\xi_1-\xi)}}{e^{2\xi_1}+1}-1\right)\cos 2\eta \qquad ..(14)$$

ACKNOWLEDGEMENT

I express my gratitude to Dr. J. P. Agrawal, Agra College, Agra for his guidance.

REFERENCES

1. Ramsay, A. S. 1954. *A Treatise on Hydromechanics*, p. 384.
2. Tranter, C. J. 1956. *Integral Transforms*, p. 80.
3. *Ibid.*, p. 79.

STUDIES ON THE EFFECT OF HIGH ENVIRONMENTAL TEMPERATURE ON THE PHYSIOLOGICAL RESPONSE OF BUFFALO

PART II. THYROID, VITAMIN A AND ASCORBIC ACID STATUS OF BUFFALO COWS DURING SUMMER.

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Subnormal thyroid activity (Nalbandov, 1958) and reduced levels of vitamin A (Ryle, 1960) and ascorbic acid (Asdell, 1949) in farm animals had been reported to be involved in reproductive failure. Blincoe and Brody (1955) found that exposure to heat depressed thyroid activity; likewise, the depressing effect of high temperature on vitamin A and ascorbic acid levels in animal body had been shown by Moore (1957) and Blincoe and Brody (1951 respectively. These observations emphasize that in investigations aimed at exploring the possible causes of infertility or subfertility in farm animals evaluation of these factors in the animal body would be of great significance. Buffaloes have been considered as seasonal breeders (Rife, 1959) showing anoestrum from April through June and a marked depression in fertility from February to July. They come in oestrus in very large number during October and November. The investigation under report was undertaken to study the involvement of the factors mentioned above in the reproductive failure of the buffaloes during the summer months. The present communication deals with the thyroid, vitamin A and ascorbic acid status of buffalo cows exposed to the prevailing weather conditions obtaining during the summer months and those provided protection from the summer stress.

METHODS AND MATERIALS

The investigation was carried out during April, May and June, which represent the hottest part of the year at Mathura. Since biological changes induced in an animal due to environmental factors can be markedly influenced by its physiological state, the animals were so selected as to do away with the interfering influences of lactation, gestation and growth. The selection of animals, the housing and management and the methods for determining the climatic elements obtaining within and outside the experimental house have been described in Part I of the series. Blood samples were drawn at 3·00 p.m. and the chemical analysis was carried out once in a month for;

(i) PBI in serum by the method recommended by Boutwell (1962); potassium iodide was used in preparing standards,

(ii) Liver vitamin A in biopsy samples obtained through the technique of Loosemore and Allcroft (1951), by the method of Gallup and Hoefer (1946), and

(iii) Serum vitamin A by the method of Kimble (1939) Ascorbic acid was determined in plasma fortnightly as described by King and Wootton (1959).

The statistical analysis was carried out according to the methods recommended by Snedecor (1956).

RESULTS

The data on serum PBI, liver and serum vitamin A and plasma ascorbic acid are given in Table 1. The PBI concentration in the unprotected animals was higher than those provided protection in the month of April. Its level showed a decline in the unprotected animals in May while in the protected group a rise was noted. The trend of change was found to have reversed during June to such an extent that the concentration was nearly equal in the two groups. Analysis of variance (Table 2) did not show significant difference in PBI concentration either between groups or between months.

The average vitamin A concentration in the liver of buffalo cows of both the groups did not differ in April. In May an increase was noted in both the groups but it was less marked in the unprotected group. During June the liver vitamin A status declined irrespective of group but the decline was more pronounced in the unprotected group and the concentration dropped below that observed at the beginning of summer. Inspite of the decline the level, however, remained higher than that observed at the start of the experiment in the protected group. The serum vitamin A had a higher average value in the unprotected animals during April. The value increased in May in the protected group while it remained constant for the unprotected animals. In June the vitamin concentration showed a sharp decline in either group but was more marked in the protected animals. The analysis of variance of liver vitamin A data showed a highly significant difference both between groups and months and also a highly significant interaction between groups and months. For the serum vitamin A such analysis revealed no significant difference between groups, while variations between months were highly significant (Table 2).

The concentration of ascorbic acid was always higher in the protected group as compared to unprotected. Analysis of variance applied to fortnightly data (Table 3) revealed a highly significant difference between groups as well as fortnights and there was a significant interaction between group and fortnights.

TABLE 1

Serum protein bound iodine (PBI), liver and serum vitamin A, and plasma ascorbic acid content of unprotected (U) and protected (P) buffalo cows during summer.

Attributes	Group	Monthly averages			Seasonal average
		April	May	June	
Protein bound iodine	U	3·96±1·27	2·61±0·27	2·98±0·35	3·19±0·44
ug/100 ml.	P	3·12±0·47	4·95±0·70	3·00±0·35	3·69±0·35
Liver vitamin A	U	47·46±5·26	49·31±6·72	39·09±5·90	45·29±3·47
ug/g fresh tissue	P	47·46±6·67	53·29±8·29	48·59±7·45	49·57±4·06
Serum vitamin A	U	39·16±4·02	40·16±2·69	27·66±1·05	35·66±2·07
ug/100 ml.	P	36·16±1·38	41·40±2·93	25·66±1·85	34·00±1·96
Plasma ascorbic acid	U	0·80±0·30	0·78±0·04	0·71±0·08	0·76±0 09
mg/100 ml.	P	1·31±0·09	1·39±0·10	1·17±0·06	1·29±0·05

TABLE 2

Analysis of variance of the data on serum PBI, liver and serum vitamin A content of unprotected and protected buffalo cows during summer

Source of variation	d. f.	Protein bound iodine		Liver vitamin A		Serum vitamin A	
		M.S.S.	'F' value	M.S.S.	'F' value	M.S.S.	'F' value
Between groups	1	1·84	0·57	160·68	21·85**	30·17	0·87
Between months	2	1·66	0·51	152·23	20·68**	639·39	18·37**
Interaction between groups and months	2	7·32	2·48	76·79	10·43**	6·50	0·18
Error	30	2·96	...	7·36	...	36·77	...

** Statistically significant at P 0·01

TABLE 3

Analysis of variance of the data on plasma ascorbic acid content of unprotected and protected buffalo cows during summer.

Source of variation	d. f.	M. S. S.	'F' value
Between groups	1	3·83	84·12**
Between fortnights	5	0·17	3·82**
Interaction between groups and fortnights	5	0·11	2·50*
Error	48	0·05	...

** Statistically significant at P 0·01 * Statistically significant at P 0·05

DISCUSSION

The depression caused by high environmental temperature on the thyroid activity of cattle is well documented. The lower PBI concentration during May as against April in the unprotected animals found in this study was indicative of thyroid depression. But the increased PBI level in June, although the environmental temperature was still higher indicated a readjustment in a thyroid activity and showed that, the animals had acclimatized themselves well. The rise of PBI level in the protected animals during May showed that the thyroid had reacted differently to the environment inside the experimental house but here too the activity was readjusted after acclimatization. Readjustment in both the instances had taken place after a long period, it was not an immediate but a delayed response (Dukes, 1955). Meites and Puntriano (1951), who worked with mice, revealed that continuous darkness increased thyroid activity and continuous light decreased it. The light factor might have influenced the thyroid function in the protected animals as they were maintained in a darkened animal house where the light was severely muffled throughout the period of study. However, the values of the serum PBI observed in both the groups of animals during summer showed that its level did not vary to such an extent as to have adversely affected the various physiological processes of the body likely to be influenced by the thyroid status (Dukes, 1955) or on the female reproductive performance specifically as suggested by Nalbandov (1958).

The average liver vitamin A content in buffalo reported by Chanda (unpublished) was 66·0 ug per g fresh tissue. The lower values of the stored vitamin A in the present experiment could be due to the limited amount of green fodder (5 kg. per day) supplied to the animals. The effect of high environmental temperature on vitamin A status was apparent from its lower concentration in the unprotected animals. However, as a considerable amount of stored and circulating vitamin A was observed in buffalo cows even after exposure to extreme summer it can be inferred that vitamin A status of buffalo cows was not altered by the high environmental temperature to a level where it could cause reproductive disorders.

The depressing effect of heat on the level of plasma ascorbic acid was evident as the unprotected animals had lower values of ascorbic acid, compared to the protected but the level again was not such as to precipitate reproductive failure.

SUMMARY

The thyroid, vitamin A and ascorbic acid status of animal are known to influence fertility and that their levels in the animal body are depressed under high environmental temperature. Their involvement in the reproductive failure of buffalo cows during summer was investigated.

Variations in the thyroid, vitamin A and ascorbic acid levels were studied in two groups of buffalo cows one protected from and the other exposed to the summer conditions.

The serum protein bound iodine level, in either group of animals, did not vary during the summer to an extent as to adversely affect the reproductive processes. Considerable amount of stored and circulating vitamin A was observed in both the groups of buffalo cows; likewise, the level of ascorbic acid was not such as to precipitate reproductive failure.

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REFERENCES

1. Asdell, S. A. 1949. *J. Dairy Sci*, **32**: 60.
2. Blincoe, C. & Brody, S. 1951. *Mo. Agric. Exp. Sta. Res. Bull.* No. **488**.
3. Blincoe, C. & Brody, S. 1955. *Ibid. Bull.* No. **579**.
4. Boutwell, J. H. Jr. 1962. Clinical Chemistry, Lea and Feliger, Philadelphia.
5. Chanda, R. (unpublished). Cited by Owen, E. C. 1965. *World Rev. Nutrit. Dietet.*, **5**: 132.
6. Dukes, H. H. 1955. Physiology of Domestic Animals, *Comstock Publ.*, N. Y.
7. Gallup, W. D. & Hoefer, J. A. 1946. *Indust. E. Engin. Chem. Anal., Ed.* **18**: 288.
8. Kimble, M. S. 1939. *J. Lab. Clin. Med.*, **24**: 1055.
9. King, E. J. & Wootton, I. D. P. 1959. Micro-analysis in Medical Biochemistry, J. A. Churchill, London.
10. Loosmore, R. M & Allcroft, R. 1951. *Vet. Rec.*, **63**: 414.
11. Meites, J. & Puntriano, G. 1951. *Endocrinol*, **48**: 217.
12. Moore, T. 1957. Vitamin A, Elsevier, Publ. Co., London
13. Nalbandov, A. V. 1958 Reproductive Physiology, W. H. Freeman and Co., San Fransisco.
14. Rife, D. C. 1959. Water Buffaloes of India and Pakistan. *Internat. Cooper. Adminis.*, Washington, D. C.
15. Ryle, M. 1960. *Aust. J. Sci.*, **23**: 36.
16. Snedecor, G. W. 1956. Statistical Methods, Iowa State College Press, Iowa.

KINETICS OF COAGULATION OF STANNIC HYDROXIDE SOL UNDER VARIOUS STAGES OF DIALYSIS

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Summary

The results obtained from the studies in the kinetics of coagulation of stannic hydroxide sol by measurements of light extinction at different stages of dialysis show the regions of slow and rapid-coagulation. It is observed that at the highest degree of purity of the sol, the extinction is low even after attaining the maximum coagulation. This has been explained on the basis of formation of lace-like structure in which the individual particles are held more loosely within the framework in the absence of regular spacing and thereby scattering lesser light and giving lower extinction values.

Introduction

In a previous publication[4] we have studied the coagulation of stannic hydroxide sol by visible technique. The present paper is concerned with the kinetics of coagulation of the sol by light extinction measurements carried out at different stages of dialysis with the addition of KCl and NaCl as the coagulating electrolytes.

As dialysis of the sol continues, its stabilising electrolyte is removed and coagulation is a more rapid process. The extent of this effect is observed by taking the extinction, or, better, its change with time, as a measure of coagulation rate and it has been seen how this rate changes with time of dialysis. The relative values of the extinction after coagulation at different stages of dialysis have been taken as a measure of the compactness of the flocs.

Experimental

The method of preparation of the sol was the same as described in the previous publication (loc. cit.). The sol was put to dialysis in a parchment paper bag for various length of time and at each stage, the conductance of the sol was determined to give the measure of its purity.

The measurements of the light extinction were made with a 'Gallenkamp' direct reading photoelectric colorimeter. The light emerging from the filter passed through the sol undergoing coagulation and finally on the photocells. The coagulation value is expressed in terms of millimoles of electrolyte per litre of final volume of the sol.

For determining the extinction of the sol, during coagulation, the pointer of the instrument was adjusted to zero by taking distilled water in a tube. A mixture of x ml. of electrolyte and (2·5 — x) ml. water was mixed with 2·5 ml.

sol (total volume being 5·0 ml. in every case) and was taken in another tube. This was inserted into the socket of the instrument; the extinction was then noted at various intervals of time.

OBSERVATIONS

The extinction values of the sol at different time-intervals and at different stages of dialysis as a consequence of the addition of varying amounts of KCl and NaCl are given in Figs. 1 and 2. Coagulation rate-concentration curves (fig. 3 and 4) have been drawn to ascertain the effect of concentration on coagulation rate. For determining the rate of coagulation of the sol, the time-extinction curves as drawn in representative Figs. 1 and 2, are used by taking that part of the coagulation curve which shows the greatest increase in extinction for a given time, i. e. $\triangle E/\triangle T$, where $\triangle E$ is the increase in the extinction value and $\triangle T$ is the corresponding time in minutes. It is observed from Figs. 3 and 4, that $\triangle E/\triangle T$ is maximum at a certain concentration of the electrolyte. This concentration is called as 'critical concentration' of the electrolyte. The values of critical concentrations of NaCl and KCl obtained from Figs. 3 and 4 have been given in table 1. In Figs. 5 and 6, the effect of increasing concentrations of KCl and NaCl on extinction values has been observed. The extinction values in this case were noted after 3 minutes of the addition of the electrolyte.

TABLE 1

Stages of dialysis	Days of dialysis	Sp. cond. $\times 10^4$ (mhos) at 30°C	Critical Conc. in mM/l	
			KCl	NaCl
I	2	21·1500	1000·0	218·8
II	4	9·4000	484·2	164·1
III	6	6·5000	302·0	128·8
IV	8	5·1200	295·1	105·9
V	10	4·1200	114·8	79·43
VI	12	3·9300	101·7	60·26

DISCUSSION

From our experimental results, it is observed (representative figs. 1 and 2) that the extinction depends on the velocity of coagulation as well as on the structure of the flocs formed. In the initial stages of dialysis when the sol contains large impurities, the addition of even a concentrated solution of electrolyte does not result in an immediate and extensive coagulation. The extinction curves do not show much increase in the beginning but do so after certain induction period. As soon as sufficient number of coagulating nuclei are formed; the extinction curves show a gradual rise. At the stage of formation of heterogeneous nuclei[7] rapid coagulation takes place and the extinction curves rise rapidly and attain maxima. In due course, when particles are sufficiently big, they settle down due to gravity and thereby the extinction begins to fall (fig. 1).

As the sol is stabilised by the potential determining ions, there is a repulsion between the sol particles. This predominates over the attraction due to London forces of attraction with the consequence that the maxima of energy is large and the flocculation value of the electrolyte is high and this may be the reason for the induction period as observed in the partially dialysed sol. In continuous dialysis, the particle charge and hence the energy of interaction of the particles decreases progressively and a point is reached where the familiar Verwey-Overbeek barrier is no longer very high with the consequence that the coagulation is accelerated and rapid coagulation starts just after the addition of dilute solution of electrolyte. The extinction curves suddenly rise as is evident in Fig. 2. As a result, the formation of a large number of coagulating nuclei and a very small rate of diffusion of small particles to the growing ones, give rise to many small highly scattering particles in which the primary particles are embedded in a haphazard way. The repulsion between the particles is more or less absent, and therefore, rearrangements in the positions of the flocs, leading to lower energy, better contact and denser structure are not possible. This is why the extinction curves (fig. 2) are flat instead of falling after passing through maxima.

It is further noted that in the case of highly purified sol, the extinction values are low even after maximum coagulation is attained. It is not because the coagulation has slowed down but because the aggregates formed are of lace-like structure in which the particles are connected irregularly, rather loose and scatter lesser light.

The difference in behaviour in the course of coagulation is caused by relatively small changes in the concentration of the coagulating electrolyte. It is observed that after the critical concentration, the coagulation seems to decrease or remain unaffected. The plots of velocity with which coagulation takes place against the concentration of the electrolyte (figs. 3 and 4) show the inflexion points at critical concentrations. Wannow[9] and Wannow and Hoffmann[8] took coagulation value of the electrolyte as the concentration at which the transmission curves show inflexion in the plots of transmission against the time of coagulation for various concentrations of the electrolyte. Troelstra and Kruyt[6] criticized Wannow's method. Tezak, Matijevic and Schulz[3, 5] proposed ten minute concentration tyndallogram for the determination of coagulation value in the case of silver halide sol in 'statu nascendi'.

It is further confirmed from figs. 5 and 6 that when coagulation takes place, the extinction of light increases causing a decrease in the intensity of light.

This change of extinction is related to the type of aggregate formed and also to the rate of sedimentation following coagulation. It is seen from figs. 5 and 6 that initially the extinction concentration curves[1] are more or less horizontal. The coagulation is accelareted with increasing amounts of electrolyte until at a definite concentration it is maximum. Considering the repulsion between the particles arising from double layers and the London forces of attraction, Hamaker[2] obtained different types of resultant curves of potential energy. For the stability of a sol it is necessary that a maximum of sufficient height, >kT, where k is Boltzmann constant and T, absolute temperature, should exist in the potential energy curves. On the addition of the electrolyte, the double layer is compressed and the neutralization of the charges takes place. In the absence of the energy barrier, the London-Van der Waals forces of attraction will prevail leading to rapid coagulation as observed by the sudden rise in the extinction curves. The repulsion between the double layers is not completely removed, therefore reorientation of the particles takes place giving rise to better contacts and denser structure. As a result of this, the particles formed are highly scattering. At higher concentrations, however, the curves begin to fall. This is because, in the absence of repulsive action between the particles, the London attraction predominates with the consequence that the particles stick where they touch each other and form loose flocs. As they have irregular surface, the scattered radiations from such surface are internally reflected with the result that the amount of scattered light is less than that by a compact spherical surface. A somewhat different behaviour is observed in the highly purified sols (V and VI stage) where the addition of even a small amount of electrolyte gives rise to lace-like structure. The partly discharged particles are attached to each other at a very few spots and in the absence of denser structure, the extinction values are low.

On going through the Table 1, it is observed that there is much difference in the coagulating ability of KCl and NaCl for the same sols. NaCl coagulates at much lower concentrations than KCl does. This effect may be due to the difference in the adsorption of the two ions (Na^+ and K^+) by the sol.

Thanks are due to Dr. A. K. Bhattacharya, D. Sc., F. R. I. C. (Lond.) and Dr. Arvind Kumar for their valuable suggestions in this work.

REFERENCES

1. H. R. Kruyt. *Colloid Science*, **I** pp. 298-299.
2. Hamaker, H. C.(1937). *Rec. Trav. Chim.*, **56**, 3.
3. Schulz, K. F., L. Kratohvil, Mirnik, M., & Vouk, V. B. (1954). *Disc.Faraday Soc.*, **18**, 63.
4. Singh, M. & Bansal, O. P. (1963) *Kolloid Z., u. Z. Polymere*, **189**, 149 .
5. Tezak, B., Matijevic, E., Schulz. K. F. (1951) *J.Phys. Colloid. Chem.*, **55**, 1557, 1567.
6. Troelstra, S. A. & Kruyt, H. R. (1943) *Kolloid Beih.*, **54**, 225.
7. Tuorila, P. (1926) *Kolloid Beih.*, **22**, 191,.
8. Wannow, H. R. & Hoffmann, K.(1936). *Kolloid--Z. u. Z. Polymere*, **80**, 294.
9. Wannow, H. R. (1936). *Kolloid-Z. u. Z. Polymere*, **77**, 46 ; (1939) *Kolloid-Beih* , **50**, 367.

FIG. 1. $Sn(OH)_4$ SOL DIALYSED FOR 2 DAYS

EXTINCTION Vs TIME CURVES

ELECTROLYTE—KCl

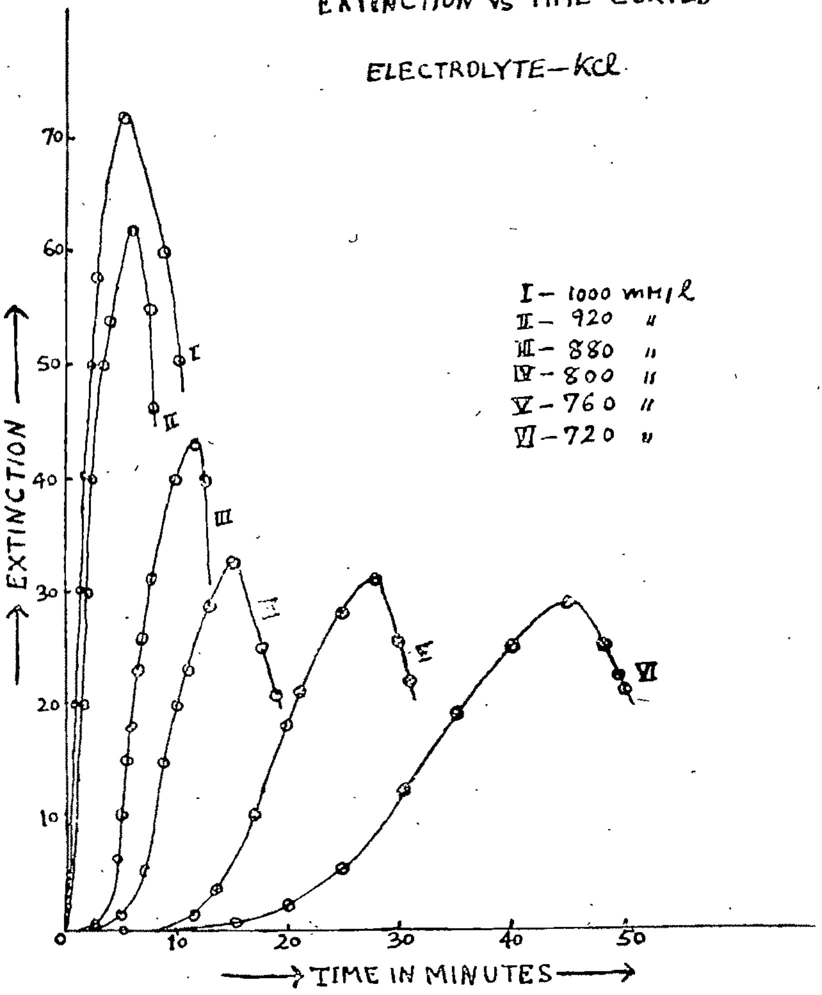


FIG. 2- $Sn(OH)_4$ SOL DIALYSED FOR 6 DAYS

EXTINCTION Vs TIME CURVES

ELECTROLYTE - NaCl.

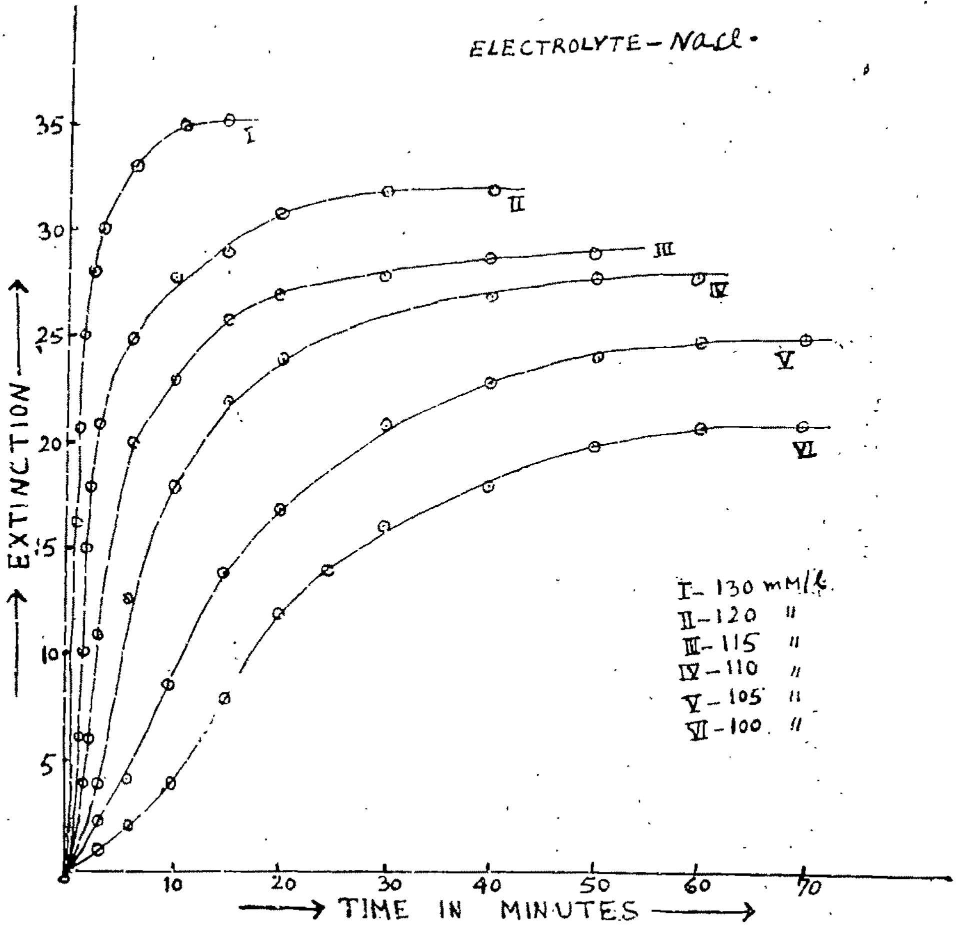


FIG. 3. ΔE/ΔT CURVES AGAINST log C AT DIFFERENT STAGES OF DIALYSIS.
ELECTROLYTE – KCl

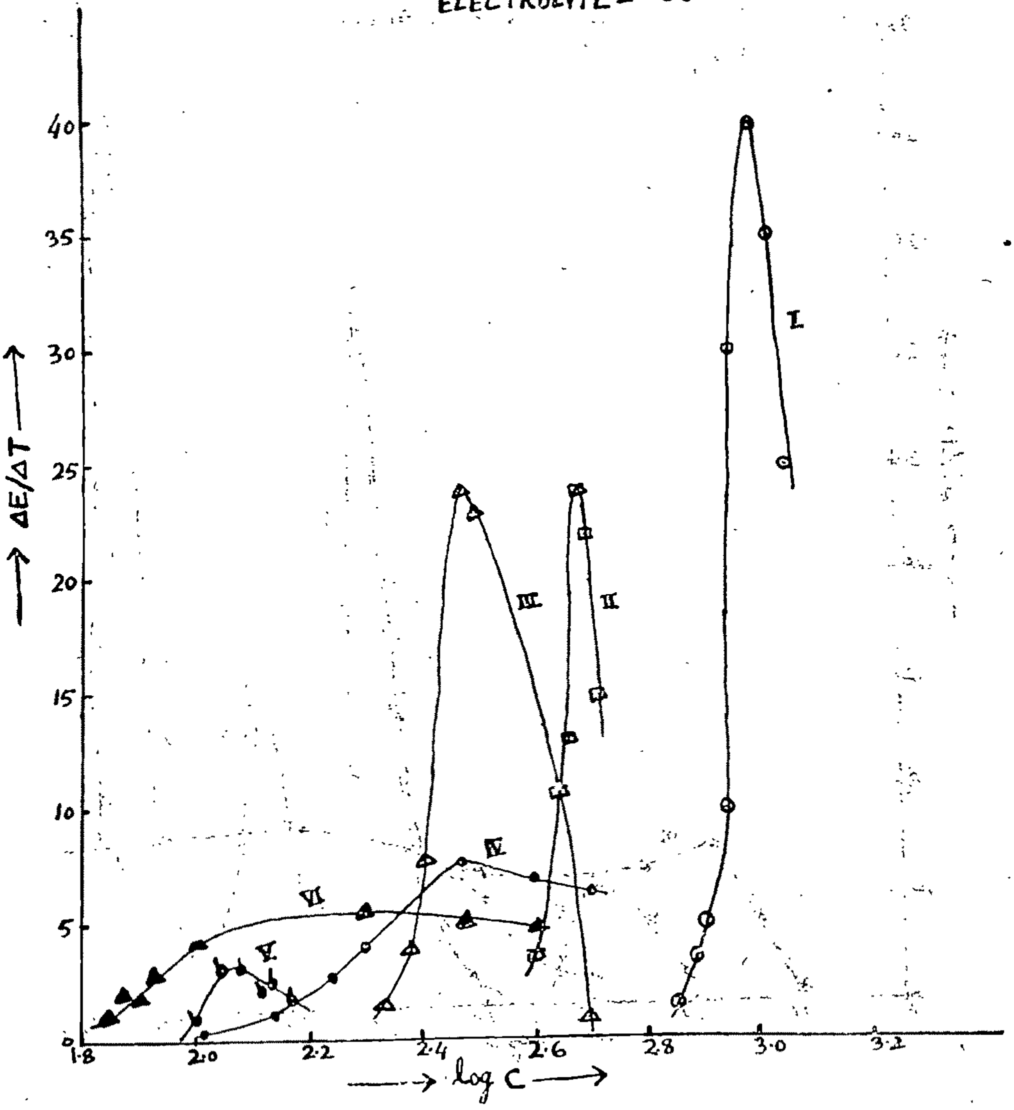


FIG. 4. ΔE/ΔT, CURVES, AGAINST log C, AT DIFFERENT STAGES OF DIALYSIS

ELECTROLYTE–NaCl.

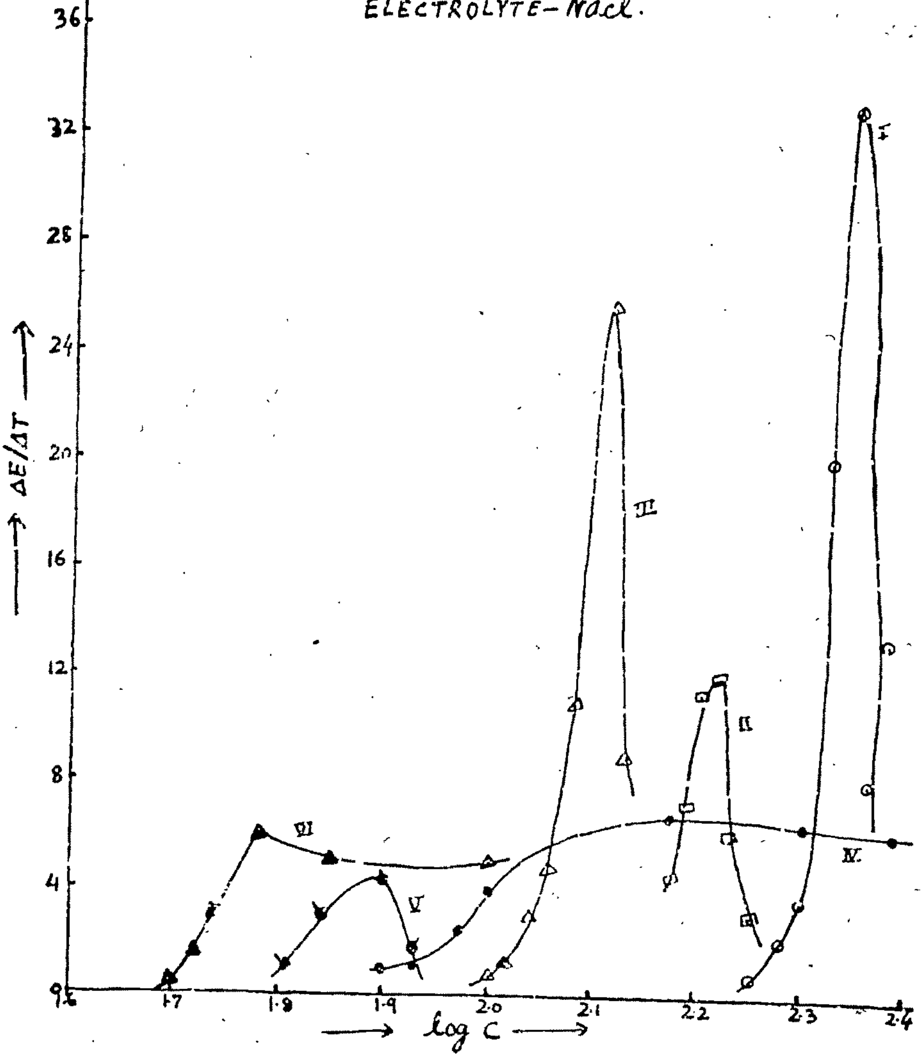


FIG. 5

EX VS CONCENTRATION CURVES AT DIFF. STAGES OF DIALYSIS

ELECTROLYTE-KCl.

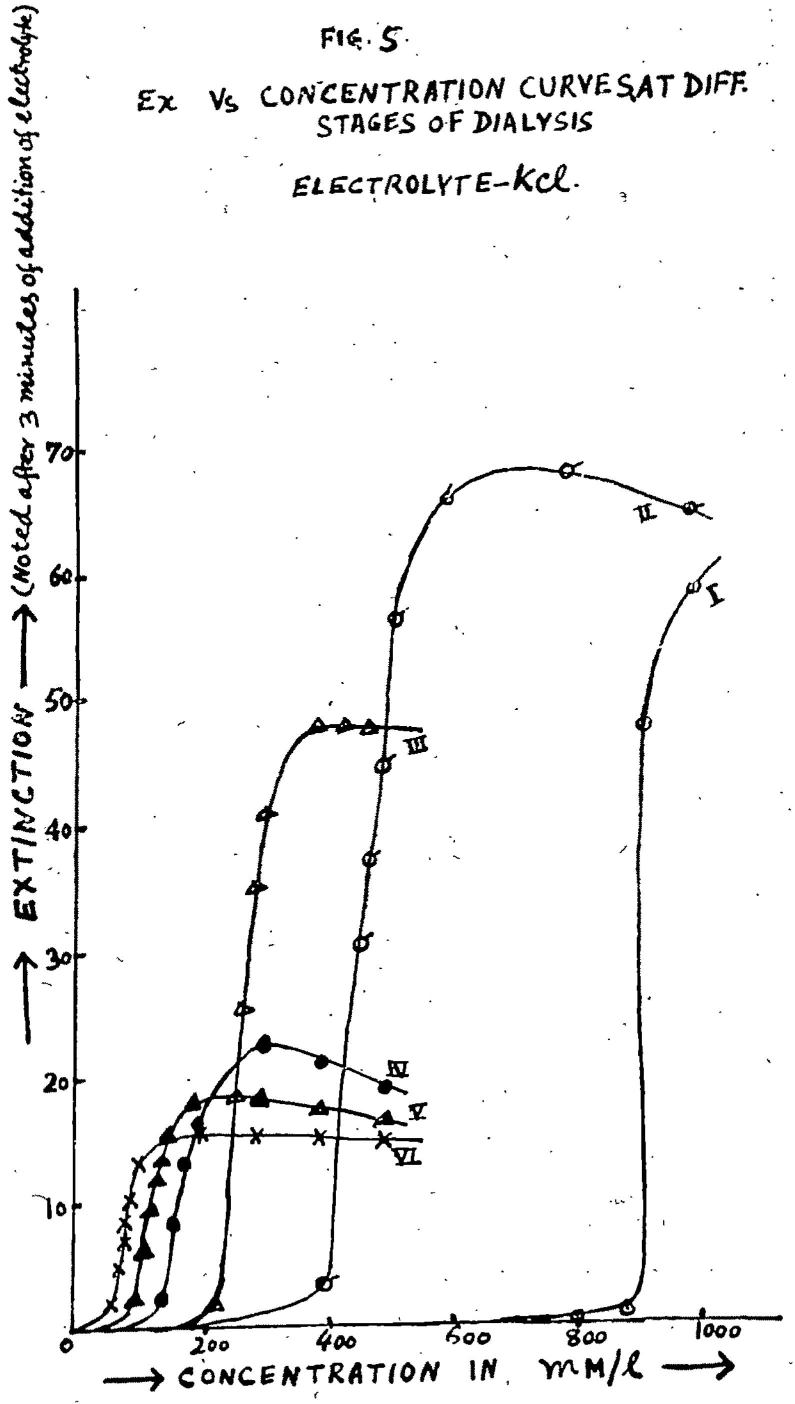
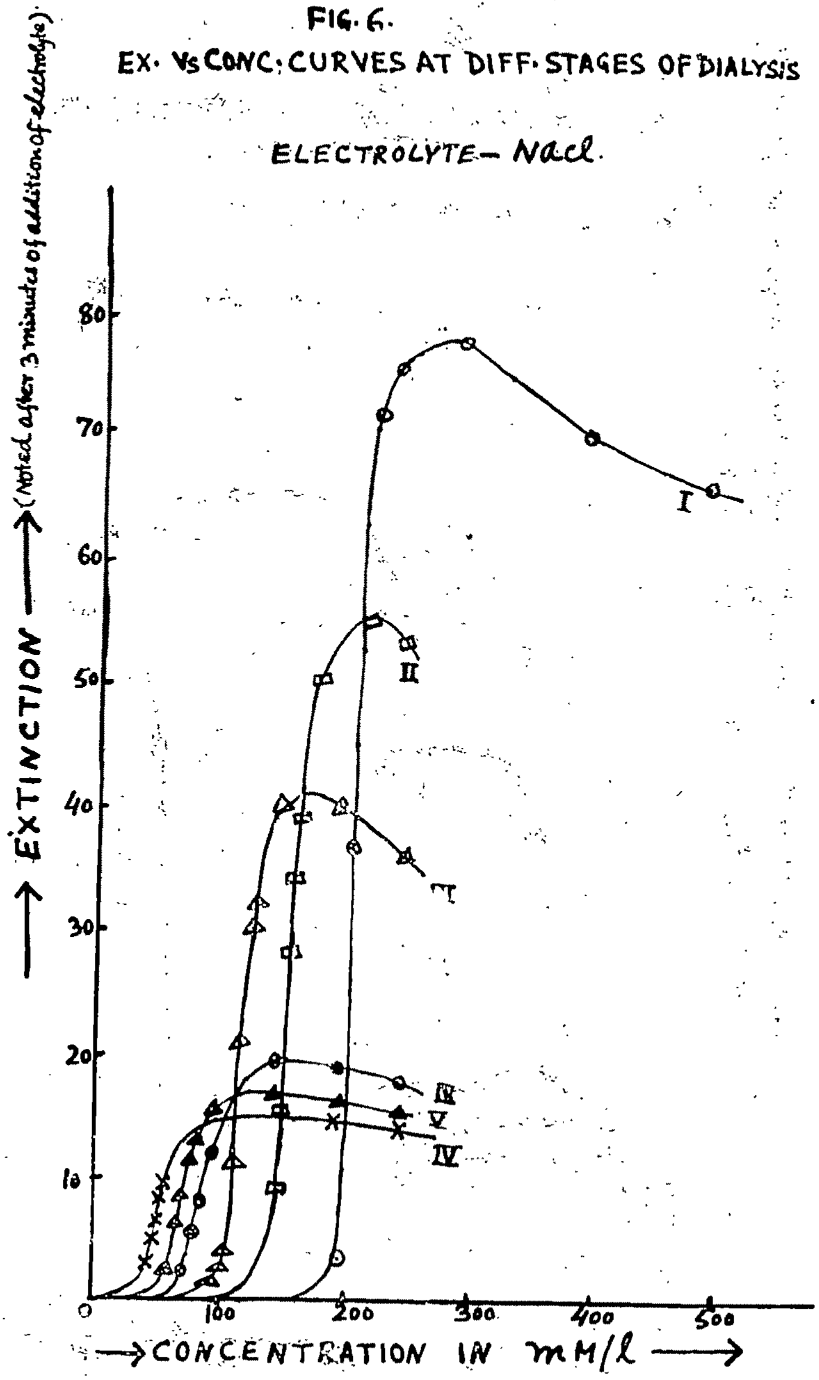


FIG. 6.

EX. Vs CONC: CURVES AT DIFF. STAGES OF DIALYSIS

ELECTROLYTE— NaCl.



ANALOGY BETWEEN THE $KMnO_4$ INDUCED REDUCTION OF MERCURIC CHLORIDE BY OXALIC, MALONIC ACIDS AND THE REDUCTION BY POTASSIUM TRIOXALATO MANGANATE (III), POTASSIUM TRIMALONATO MANGANATE (III) COMPLEXES ALONE

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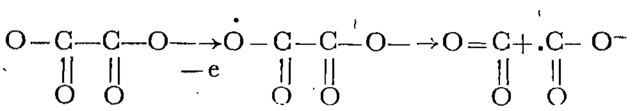
Summary

A comparative study was undertaken on the reduction of mercuric chloride by (a) oxalic and malonic acids with potassium permanganate as inductor and (b) potassium trioxalato manganate (III) and trimalonate manganate (III) complexes alone. The data support the earlier views that an intermediate complex is formed as a result of interaction between potassium permanganate and the acid in the $KMnO_4$ induced reduction of mercuric chloride.

Introduction

The reaction between potassium permanganate and oxalic acid has been studied by a number of workers. According to Skrabal[9] Mn^{2+} ion is an intermediate product in the reaction due to the formation of some manganese (III) complex. Launer[6] explained the mechanism of the reaction by the intermediate formation of a complex $[Mn(C_2O_4)_2]^-$. Lidwell and Bell[7] and Basset and Senderson[2] observed that H^+ ions accelerated the reduction of Mn^{3+} ions to Mn^{2+}. Oxalic acid does not reduce mercuric chloride but when mixed with potassium permanganate it does so readily. The reduction of mercuric chloride by oxalic acid in presence of potassium permanganate has been explained by previous workers[3,12] on the basis of the formation of an intermediate free radical $C_2O_4^-$ $(Hg^{2+}+C_2O_4^- \rightarrow Hg^+ + 2CO_2)$. The work of Taube[10], Waters[11] and Malcolm and Noyes[8] *highlight* the formation of an intermediate free radical which may be either I or II as shown below.



$$\mathrm{O{-}\underset{\underset{O}{\|}}{C}{-}\underset{\underset{O}{\|}}{C}{-}O} \xrightarrow[-e]{} \mathrm{\dot{O}{-}\underset{\underset{O}{\|}}{C}{-}\underset{\underset{O}{\|}}{C}{-}O} \rightarrow \mathrm{O{=}\underset{\underset{O}{\|}}{C}+{.}\underset{\underset{O}{\|}}{C}{-}O^{-}}$$

I II

In the present paper we have carried out a comparative study on the reduction of mercuric chloride by potassium trioxalato manganate (III) and potassium trimalonato manganate (III) and the reduction by oxalic and malonic acids in presence of potassium permanganate as inductor.

Experimental

The complexes potassium trioxalato manganate (III) and potassium dimalonato diaqua manganate (III) were synthesised by the method as reported in literature[4],[5]. Potassium dimalonato diaqua manganate (III) was dissolved in malonic acid solution in order to obtain potassium trimalonato manganate (III).

$$[Mn\,(C_3H_2O_4)_2(H_2O)_2]^- + C_3H_2O_4^{2-} \rightleftharpoons [Mn(C_3H_2O_4)_3]^{3-} + 2H_2O.$$

For studying the kinetics, 100 ml of 0.01 M mercuric chloride solution was taken in different conical flasks kept in a thermostat maintained at a desired temperature. The reaction was started by adding to each flask a constant weight of the oxalato complex in the crystalline form. In the case of malonato complex, a solution of potassium dimalonato diaqua manganate (III) in malonic acid was added. Since these complexes are very unstable in aqueous medium even at very low temperature, their aqueous solutions could not be used. The experiment was repeated by taking different amounts of the complexes at different temperatures. Similar results were obtained. The kinetics of the induced reduction of mercuric chloride was studied as described in our previous publication[1]. The results have been recorded graphically (fig. 1). The changes in conductivity during the reaction were also noted by means of a Kohlrauschs bridge and observations are given in fig. 2.

OBSERVATIONS AND DISCUSSION

It is observed that the *x-t* curves for the reduction of mercuric chloride by oxalic and malonic acids induced by potassium permanganate [fig. 1 curves 1(a) and 2(a)] are similar to those obtained for the reduction of mercuric chloride by the corresponding oxalato and malonato complexes of trivalent manganese alone [fig. 1 curves 1(b) & 2(b)]. The only difference observed is, that in the case of acids there is an induction period i.e. the reduction of mercuric chloride starts after a time interval after mixing the reactants, but when the complexes are used the reduction starts almost instantaneously.

It is observed from fig. 1 that the reduction of mercuric chloride by the acids in presence of potassium permanganate as an inductor as well as its reduction by the complexes alone shows first autocatalysis and then autoinhibition followed by a normal reaction. From this it can be inferred that the reduction of mercuric chloride in both the cases is governed by a similar mechanism involving a common active substance responsible for the reduction, which may be produced in both the systems. This confirms the views of previous authors (loc. cit.) that in the "acid-$KMnO_4$-$HgCl_2$" system first potassium permanganate and the acid form an intermediate complex which may either be $K_3Mn(C_2O_4)_3$ or $K_3Mn(C_3\,H_2O_4)_3$ or of a similar nature in the respective systems. The period of induction in the $KMnO_4$ induced reduction of mercuric chloride can now be said to be the time lag for the formation and subsequent decomposition of this complex.

Conductivity variations during the entire course of the reaction throw more light on the views discussed above. From fig. 2 it is seen that initial variations in the conductivity take place in the case of "acid-$KMnO_4$-$HgCl_2$" system only up to the period of induction [curves 1(a) and 2(a)]. In the case of the reduction by complexes, however, there is practically no change in conductivity during the whole course of the reaction [curves 1(b) & 2(b)] and the nature of the curve is the same as that for the induced system after the initial variations. This is suggestive of the fact that the $KMnO_4$ induced reduction, after an initial induction period, follows the same trend as in the case of the reduction with complexes.

The initial fall in conductivity in the induced reduction is an indication of some complex formation. On decomposition of the complex $C_2O_4^{2-}$ ions are furnished as shown by equation 1 and 2.

$$[Mn(C_2O_4)_3]^{3-}+2H_2O \rightleftharpoons [Mn(C_2O_4)_2(H_2O)_2]^{-}+C_2O_4^{2-} \qquad ..(1)$$

(oxalic acid-$KMnO_4$ system)

$$[Mn(C_3H_2O_4)_3]^{3-}+2H_2O \rightleftharpoons [Mn(C_3H_2O_4)_2(H_2O)_2]^{-}+CH_2C_2O_4^{2-}$$

$$CH_2C_2O_4^{2-} \longrightarrow CH(OH)C_2O_4^{2-} \longrightarrow CHO.COO^{-} \longrightarrow C_2O_4^{2-} \qquad ..(2)$$

(Malonic acid-$KMnO_4$ system).

Accordingly there should have been a rise in conductivity, but on constancy is being observed which may be attributed to the simultaneous employment of $C_2O_4^{2-}$ ions thus liberated for the reduction of mercuric chloride.

$$C_2O_4^{2-}+Mn^{3+} \longrightarrow CO_2^{-}+CO_2+Mn^{2+} \qquad ..(3)$$

$$Hg^{2+}+CO_2^{-} \longrightarrow Hg^{+}+CO_2 \qquad ..(4)$$

That a straight line parallel to the time axis is obtained in the case of the reduction of mercuric chloride by complexes alone is in support of the above view.

The variations in pH during the $KMnO_4$ induced reduction of mercuric chloride by oxalic and malonic acid were noted and the results are shown in fig. 3. It is seen from the figure that the pH of the reaction mixture remains constant for a short period in the beginning of the reaction after which it rises. This observation can be explained on the basis of the above discussions. It is the anion of the acid ($C_2O_4^{2-}$ or $CH_2C_2O_4^{2-}$) which is involved in the formation of the intermediate complex as stated above. The cation i.e. the H^+ ion of the acid remains uneffected and hence pH remains constant. When CO_2^- radicals begin to form (equ[3]) there is an interaction between the CO_2^- radical and oxygen in the reaction mixture with the formation of O_2^- ($CO_2^-+O_2 \longrightarrow CO_2+O_2^-$), which in turn removes H^+ ions according to the following mechanism, resulting in a rise in pH of the system.

$$O_2^{-}+H^{+} \longrightarrow HO_2$$

$$HO_2+e^{-} \longrightarrow HO_2^{-}$$

$$HO_2^{-}+H^{+} \longrightarrow H_2O_2$$

Oxygen in the reaction mixture is produced by OH radicals ($2OH \longrightarrow H_2O + O$) which are formed by the interaction of Mn^{4+} ion and a water molecule ($Mn^{4+} + H_2O \longrightarrow Mn^{3+} + OH + H^+$). Mn^{4+} ions are produced by the disproportionation of Mn^{3+} ions into Mn^{4+} ion ($2Mn^{3+} \longrightarrow Mn^{4+} + Mn^{2+}$) (Cullis and Ladbury).

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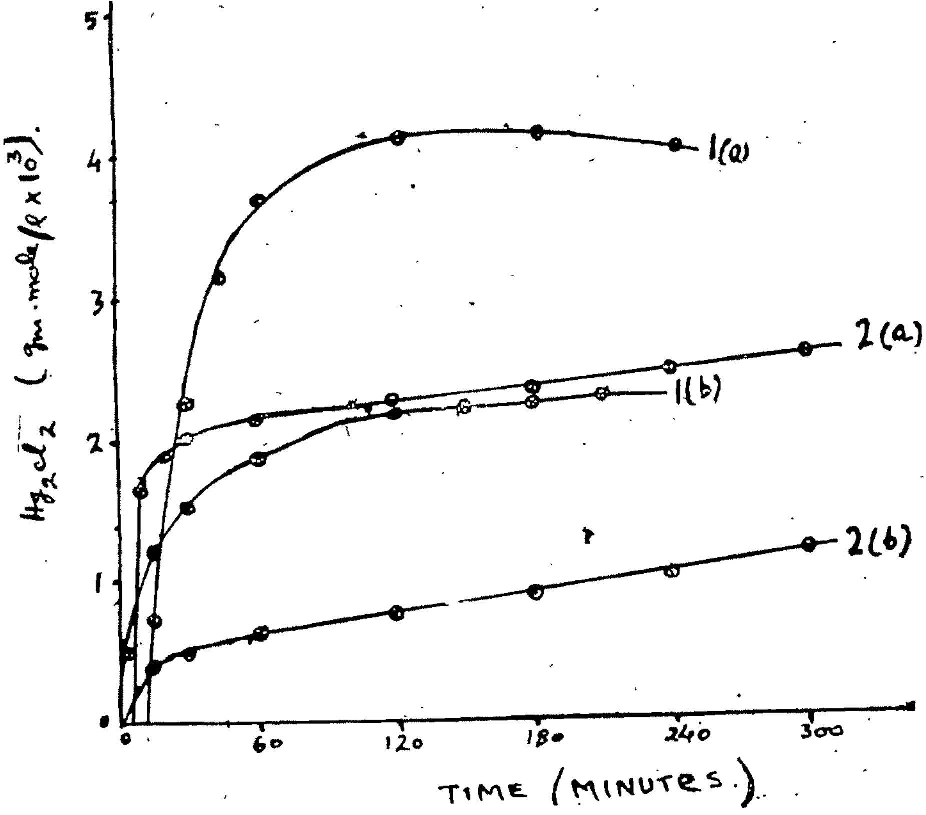
REFERENCES

1. Bansal & Mathur, *J.I.C.S.*, 1965, **42** (4) : 233, 235.
2. Besset & Senderson, *J.C.S.* 1936, 207.
3. Cartledge, *J.A.C.S.*, 1941, **63** : 906.
4. Cartledge & Ericks, *J.A.C.S.*, 1936, **58** : 2061, 2065.
5. Cartledge & Nichols, *J.A.C.S.*, 1940, **62** : 3057.
6. Launer, *J.A.C.S.* 1932, 54, 2597, 1933, 53, 865.
7. Lidwell & Bell *J.C.S.*, 1935, 1303.
8. Malcolm & Noyes, *J.A.C.S.* 1952. **74** : 2769.
9. Skrabal, 1904. *Z. Inorg. Chem.* **42** : 1.
10. Taube, *J.A.C.S.*, 1947, **69** : 1418; 1948, **70** : 1216.
11. Waters, W.A. "Mechanism of oxidation of organic compounds", Mathuen & Co. Ltd., 1964, p. 104.
12. Weiss J. Discussion Faraday Society, 1947, **2** : 188.



Curves.

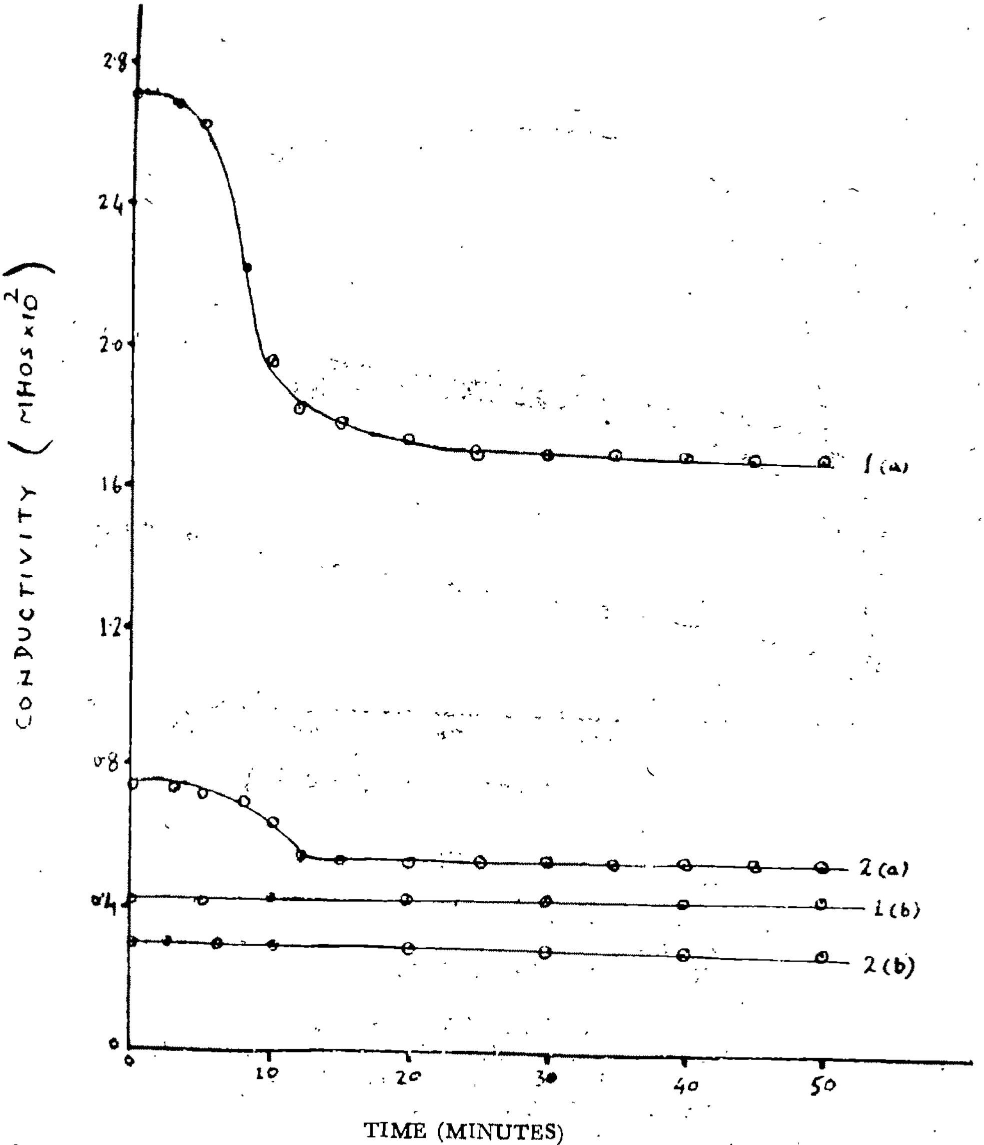
1(a). Oxalic acid=0·1 M, $HgCl_2$=$KMnO_4$=0·01M
Temp.=25°C.
Induction period=12 mins.

1(b). Oxalate Complex=0·2 gms.
$HgCl_2$=0·01 M, Temp.=25°C.
Induction period=0 min.

2(a). Malonic acid=0·1 M, Hgcl₂=$KMnO_4$=0·01 M
Temp.=35°C, Induction period=4 mins.

2(b). Malonate complex=0·2 gms. in 0·02 M malonic acid solution.
$HgCl_2$=0·01 M, Temp.=40°C.
Induction period=0 min.

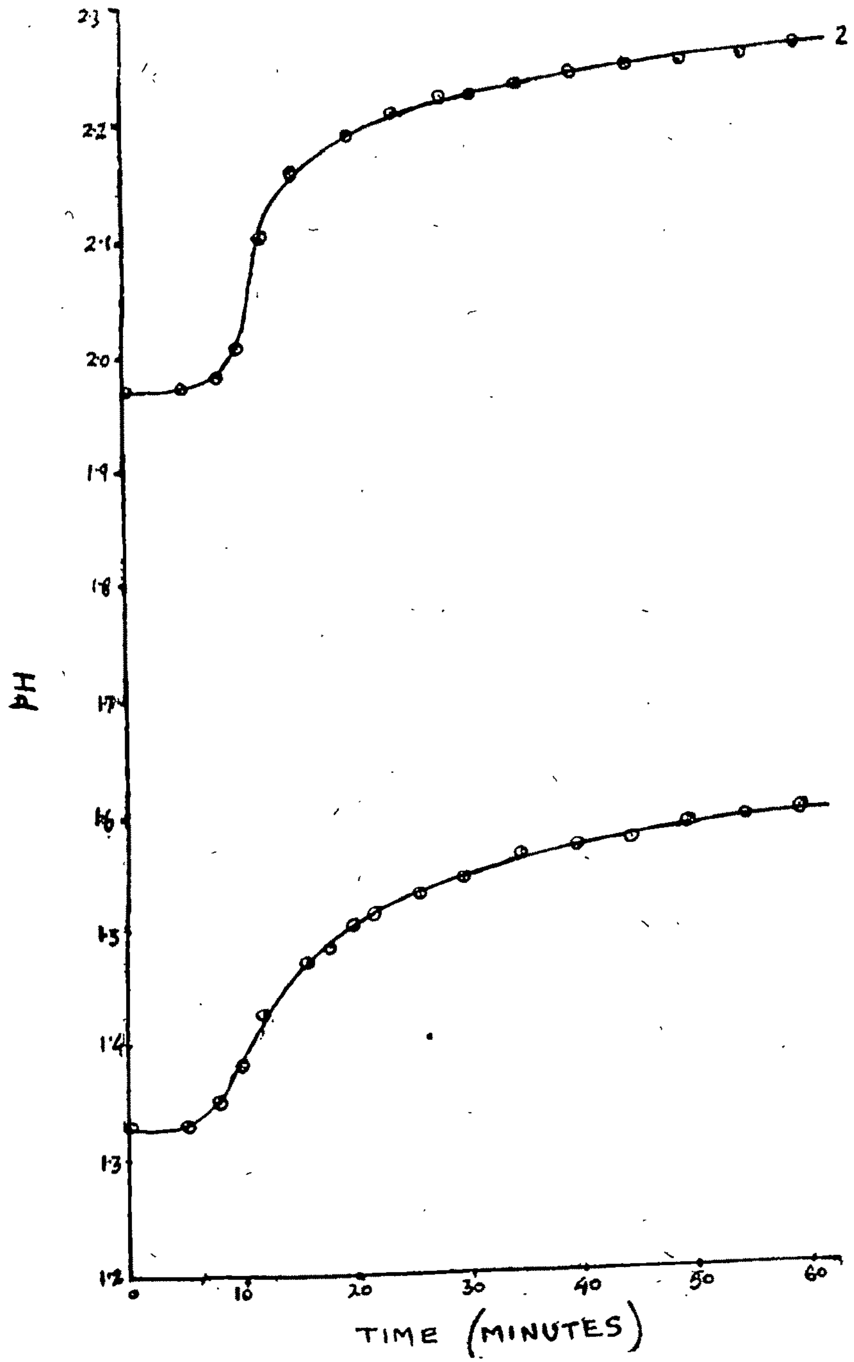
Fig, 1. Comparative study on the reduction of mercuric chloride by oxalic and malonic acids induced by $KMnO_4$ and the reduction by the oxalate and malonate complexes of Mn(III) alone.



Curves

1(a) Oxalic acid—KMnO$_4$—HgCl$_2$ system.
1(b) Oxalate complex—HgCl$_2$ system.
2(a) Malonic acid—KMnO$_4$—HgCl$_2$ system.
2(b) Malonate complex—HgCl$_2$ system.

Fig. 2. Changes in conductivity during the reduction of mercuric chloride by oxalic and malonic acids and the reduction by oxalate and malonate complexes of trivalent manganese alone.



Curves

(1) Oxalic acid $-$ $KMnO_4$ $-$ $HgCl_2$ system.

(2) Malonic acid $-$ $KMnO_4$ $-$ $HgCl_2$ system.

Fig. 3. Changes in pH during the reduction of mercuric chloride by oxalic and malonic acids induced by $KMnO_4$.

TOPOGRAPHICAL STUDIES OF THE BRAINS OF SOME FRESH WATER TELEOSTS

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Introduction

By the study of the literature, it was found that little work has been done on the brains of Indian fishes. The more recent and important references are those of Evans (1931,32), Bhimachar (1935,37,45) and Mookerjee, Ganguly and Mookerji (1950). All of them tried to establish a correlation between the feeding habits of the fishes and the structural modifications of the different parts of the brain. For the present study, four fishes of different feeding habits, *Clarias batrachus*, *Labeo gonius*, *Notopterus notopterus* and *Mastacembelus armatus* have been selected. The former two feed by vision and taste, *Notopterus notopterus* feeds mainly by vision whereas *Mastacembelus armatus* feeds mainly by taste. The fishes were collected from the local fish market of Muzaffarnagar. Their brains were dissected carefully and were fixed in situ in aquous Bouins solution. The brains were also preserved in 70% alcohal.

Observations

The brain of all the fishes is lodged with in the cranial cavity which is filled with a gelatinous fluid. As in other vertebrates, the brain is divided into prosencephalon (fore-brain), mesencephalon (mid-brain) and rhombencephalon (hind-brain). The prosencephalon comprises the telencephalon and diencephalon; the mesencephalon includes only the optic lobes while the rhombencephalon consists of cerebellum and medulla oblongata. There are, however, notable differences in the different parts of the brains in the different fishes.

Clarias batrachus

(Figs., 1 and 2)

In a fish of about 251 mm. long, the brain was found to be 36 mm. long.

Prosencephalon

The olfactory lobes are absent, each however, appears to be divided into an olfactory tract and olfactory bulb. The olfactory tracts are dilated at their bases, as club-shaped structures which lie along the inner ventral surfaces of the cerebral hemispheres. The base, measures about 2·5 mm. in length and 1·0 mm. in maximum width. The olfactory tract runs forward and finally enlarges as olfactory bulb immediately behind the olfactory sac. Each olfactory bulb (OL. B) measures about 2·6 mm. in length and 2·1 mm. in maximum width; it is somewhat rounded in shape.

The cerebral hemispheres (C.H) are paired structures and are placed anteriorly and cover the lobe-like bases of the olfactory tracts completely from the dorsal side. Each lobe is oval in shape and measures about 4·0 mm. in length and 3·0 mm. in width. The paired cerebral hemispheres are smooth dorsally, being convex on the outer and inner sides. They come in contact in the mid-line. Postero-mesially, they are covered by the forward prolongation of the cerebellum.

The diencephalon is narrow and remain covered over dorsally by the forward prolongation of the cerebellum. From the floor of the diencephalon just behind the crossing over of the optic nerves, is given off the infundibulum (INF.) which bears at its free end an oval pituitary body (PT. B.). The saccus vasculosus is absent. On either side of the saccus lie the prominent inferior lobes of diencephalon. Each inferior lobe (I.L.) measures about 4·2 mm in length and 3·0 mm. in maximum width. The pineal body is present.

Mesencephalon

The optic lobes (OP.L.) are comparatively better developed. Due to the forward prolongation of the cerebellum, the optic lobes are partially covered over and are shifted to the sides so as to take the lateral positions. Ventrally the optic lobes are hidden by the inferior lobes of the medulla oblongata. Each optic lobe is oval in shape and measures about 3·0 mm. in diameter. The optic nerves are long, cross each other and are partially fused at the base.

Rhombencephalon

The cerebellum (C.B.) is a median elongated and dorso-ventrally compressed structure; it being more or less pear-shaped. It is comparatively well developed in this fish and measures 9·0 mm. in length and 7·5 mm. in maximum width. Anteriorly it extends and covers the posterior 1/3 of the cerebrum; in doing so it also covers and displaces the optic lobes on the sides. From the postero-lateral corners of the cerebellum arise curved distally pointed prominent processes which make the outer boundary of antero-lateral half of the facial lobe of the medulla oblongata. These processes are called dorsal acoustic tubercles (A. T B.). The acoustic tubercle which measures 3·5 mm. are convex towards the outer sides and concave towards the inner sides.

The medulla oblongata (M.O.) is a roughly triangular structure which is about 7·0 mm. in length and 4·5 mm. in maximum width. Posteriorly, it is continued into the spinal cord, while anteriorly it embraces the optic lobes. The dorsal surface of the medulla is marked by the presence of two prominent swellings on either sides. The anterior swelling is comparatively bigger than the posterior and is called the facial lobe. The posterior swelling is termed as the vagal lobe. The facial lobes (FL. L.) are oval and each measures about 3·5 mm. in length and 2·5 mm. in maximum width They meet each other in the mid-line. The vagal lobes (V.L.) are oval and long in appearance and each measures about 2·7 mm. in length and 1·8 mm. in maximum width. The vagal lobes meet medially with each other at the posterior end and then the two vagal lobes diverge, leaving a wide groove in between them.

NOTOPTERUS NOTOPTERUS

(Fig. 3 and 4)

In a fish of about 234·0 mm. long the brain was found to be about 28·5 mm. long.

Prosencephalon

The olfactory bulbs (OL. B.) are well developed and are elongated as compared to other fishes studied here. Each bulb measures about 4·0 mm. in length and 3·0 mm. in maximum width. The flattened olfactory tracts are of medium length, each measures about 9·0 mm. in length and about 0·5 mm. in width. The olfactory lobes are, however, absent in this fish.

The cerebral hemispheres (C.H.) are highly developed when compared with other fishes and possess furrows on the dorsal and lateral sides. The size of each cerebral hemisphere was found to be 5·5 mm. in length and 4·0 mm. in width.

The diencephalon is narrow band-like structure and is better developed in comparision to other fishes studied here. Slender thread-like pineal stalk is also present. The floor of diencephalon possesses the infundibulum which bears the pituitary body (PT.B.) at its free end. The pituitary body is well developed with a large saccus vasculosus lying postero-dorsal to it.

Mesencephalon

The optic lobes (OP.L.) are highly developed, each measuring about 6·0 mm. in length and 4·5 mm. in maximum width. Optic lobes are more or less spheroidal in shape and meet medially where they are demarcated by a deep groove. On the ventral side of the optic lobes are found large bean-shaped lobes, the inferior lobes. The optic nerves simply cross each other ventrally infront of infundibulum without forming a true optic chiasma.

Rhombencephalon

The cerebellum (C.B.) is of moderate size with broader anterior and narrower posterior end. The cerebellum is a dorso-ventrally compressed structure. It measured 4·5 mm. in length and 3·0 in width.

The medulla oblongata (M.O.) is roughly triangular and elongated structure of about 8 0 mm. long and 5·0 mm. width. The anterior part of the medulla is not very much swollen. The facial lobe of medulla is developed while the vagal lobe is not well marked. On the lateral sides of the medulla oblongata are present inferior lobes (I.L.), which can be seen from the ventral side of the brain These lobes embrase the saccus vasculosus (S.V.) in between them. Each inferior lobe measures about 3·0 mm. in length and 1·0 mm. in width.

LABEO GONIUS

(Figs. 5 and 6)

In a fish about 263 mm. long, the brain was found to be about 32·0 mm in length.

Prosencephalon

The olfactory lobes (OL.L) are absent. The olfactory tracts arise from below the cerebral hemispheres. At their bases, they are too broad. Each tract is about 13·0 mm. in length and 0·2 mm. in diameter. Anteriorly, they enlarge to form somewhat oval structures; each expands cup-like at its anterior extremity. The size of the olfactory bulb (OL.B.) is about 2·5 mm. in length and 2·0 mm. in width.

The cerebral hemispheres (C.H.) are paired structures and cover a part of the olfactory tract from the dorsal side. In structure, each lobe is oval in shape and measures about 4·5 mm. in length and 3·5 mm. in width. The cerebral hemispheres in *Labeo gonius* like other fishes are smooth; being convex dorsally and laterally while ventrally it is somewhat concave. The two lobes of the cerebral hemisphere are separated by a well marked deep straight median groove.

The diencephalon is very much reduced as compared to other fishes studied here. Pineal body is not well marked in this fish. From the floor of the diencephalon, just behind the crossing of the optic nerves, is given off the infundibulum (INF.) which bears the pituitary body (PT.B.) at its free end. The saccus vasculosus is absent. On each side of the pituitary body lie the prominent inferior lobes (I.L.) of diencephalon which can be well seen from the ventral view.

Mesencephalon

The optic lobes (OP.L.) are comparatively better developed; each being about 4·0 mm. in length and 3·5 mm. in width. On the ventral surface of the optic lobes are found large bean-shaped inferior lobes. The optic lobes are rounded structures and are shifted to the sides so as to take the lateral positions. The median grooves separating the two lobes is very deep. They are not covered over by the cerebellum dorsally. The optic nerves cross one another ventrally and are fused at the base.

Rhombencephalon

The cerebellum (C.B.) is very large structure being bent on itself. The anterior part of the cerebellum is pushed forward under the roof of the mesencephalon to form the valvula cerebri. The cerebellum is a dorso-ventrally compressed and more or less pear-shaped structures. It measures 6·0 mm. in length and 5·0 mm. in width. From the antero-lateral corner of each side of the cerebellum arises a curved pointed prominent process which cover the facial lobes antero-laterally.

The medulla oblongata (M.O.) is roughly triangular and elongated structure of about 9·0 mm. in length and about 3·5 mm. in width. Anterior part of medulla is very much swollen while posteriorly it is greatly reduced in its size and is then continued behind as the spinal cord. The facial lobes (FL.L.) are oval in shape and meet with each other in the mid-line. Each lobe measures about 3·7 mm. in length and 2·8 mm. in width. At the junction of the vagal lobes is left a small groove in between them.

MASTACEMBILUS ARMATUS

(Figs. 7 and 8)

In a fish about 375 mm. long, the entire brain measured about 30·5 mm. in length.

Prosencephalon

The olfactory lobes (OL. L.) are paired structures situated antero-ventral to the cerebral hemispheres. They meet each other in the middle line where they remain separated by means of well marked median groove. Each olfactory lobe is small, roughly globular but elongated structure with broad base. It measures about 2·5 mm. in length and 1·5 mm. in width. The lobes are continued forward as an olfactory nerves. Postero-dorsally they meet the cerebral hemispheres. The olfactory bulbs are absent.

The cerebral hemispheres (C.H.) are paired rounded structures lying anteriorly where they partly cover the olfactory lobes. The two lobes of the cerebral hemispheres meet medially with each other where they are separated by a median deep groove. They are smooth dorsally and are convex on the outer sides while they are almost straight towards the inner sides. Each cerebral hemisphere is comparatively less developed and measures about 3·0 mm. in length and 1·5 mm. in width.

The diencephalon is very small. Ventrally it gives rise to the infundibulum (INF.) as a very simple outgrowth below the crossing of the optic nerves. At its free end, the infundibulum is closely associated with the pituitary body (PT.B.). On either sides of pituitary body lie prominent swellings, the inferior lobe (I. L.) of diencephalon. The saccus vasculosus being absent.

Mesencephalon

The paired optic lobes (OP.L.) are well developed and each measures about 3·5 mm. in length and 2·0 mm. in width. From the antero-mesial ends of the optic lobes arise thick optic nerves, which cross each other ventral to the diencephalon. They do not fuse at the base.

Rhombencephalon

The cerebellum (C.B.) is also a well developed and conspicuous structure which is arched dorso-ventrally. The anterior part of the cerebellum grows upto the mid-brain so that the optic lobes become arched posteriorly. The cerebellum measures about 4·5 mm. in length and 4·3 mm. in width. It is broad anteriorly and slightly narrower posteriorly. In external appearance, it is convex anteriorly concave laterally and ventrally. It carries a pair of antero-lateral outgrowths; one on each side.

The medulla oblongata (M.O.) is a triangular structure being broad at its anterior end and tapers posteriorly to continue as the spinal cord. The medulla is well developed and measured about 7·5 mm. long and 2·0 mm. in maximum width. It is depressed antero-dorsally to accommodate the cerebellum with the result it is raised slightly on the ventral side. The facial and vagal lobes are not marked externally.

DISCUSSION

The brain of all the fishes studied here though follow the same teleostean pattern yet possess certain special features, which require comments.

1. The most important feature of the brain of *Clarias batrachus* and *Labeo gonius* is the great development of facial and vagal lobes of the medulla oblongata and moderate size of the optic lobes. These features of the brain can easily be correlated with the fact that the fishes mainly feed by the gustatory sense organs or taste buds which are present over the different barbeles of the fishes and by the vision. Herrick (1905) stated that the variations in the structure of the medulla oblongata depend on the distribution of the taste buds. Evans (1931) and Bhimachar (1935) classified the fishes into three and two main groups respectively considering their feeding habits in relation to their brains. In this condition *Clarias batrachus* and *Labeo gonius* are very similar to that of *Heteropneustes fossilis*, *Wallago attu* (Mookerjee, et al. 1950) which also select their food by sight, the taste present on the barbels and the snout.

2. In *Clarias batrachus* and *Labeo gonius* the cerebellum is better developed than in other fishes studied here; however, in *Clarias batrachus* it further extends anteriorly for a short distance, thus confirming the views of Mookerjee, et al (1950) that the active feeders possess the large sized cerebellum. The cerebellum of *Mastacembelus* is not so well developed as the fish confines most of its activities to the bottom. Thus *Mastacembelus armatus* presents a contrast to that of *Clarias batrachus* and *Labeo gonius* which are active swimming fishes, where the need for the keen sense has resulted in the great development of cerebellum. The cerebellum of *Notopterus notopterus* is of moderate size with a broad anterior and narrower posterior end. In this respect the fish is more nearer to *Labeo* and *Clarias*.

3. The optic lobes of *Notopterus notopterus* like that of *Wallago attu*, *Nandus nandus* and *Ophicephalus guchia* (Mookerjee, et al 1950) are highly developed and are more or less spherical in shape. This feature of *Notopterus notopterus* can be easily understood as the fish mainly feeds on the surface flora and fauna by sense of vision. The optic lobes of *Clarias batrachus* and *Labeo gonius* are also

well developed but not, as in *Notopterus* which feeds mainly by vision. *Mastacembelus* possesses comparatively less developed optic lobes as it feeds mainly by taste.

4. In the fishes, *Mastacembelus armatus* and *Notopterus notopterus* the paired optic nerves do not form the optic chiasma, but simply cross each other and there is no exchange of nerve fibres. A similar condition has been reported in *Sciaenoides brunneus* (Karandikar and Thakur, 1954). However in *Clarias batrachus* and *Labeo gonius* the optic nerve partially fuse at the crossing infront of diencephalon.

5. Olfactory lobes are absent in *Clarias*, *Notopterus* and *Labeo* but are present in *Mastacembelus*. It seems that where they are absent, they are divided into olfactory tracts and olfactory bulbs. The olfactory bulbs are best developed in *Notopterus notopterus*, better developed in *Clarias batrachus* and *Labeo gonius* and absent in *Mastacembelus armatus*. In *Clarias batrachus*, *Labeo gonius* and *Notopterus notopterus*, it can be argued that this well developed olfactory bulbs may suggest Mookerjee, et al's. 1950 findings who suggested better developed olfactory bulbs in bottom feeder fishes. The olfactory bulbs in the bottom feeders play some role in the selection of food is further supported by the investigation of Sato (1937) on the Japanese catfish, *Plotosus anguillaris*. It is further argued that the olfactory bulbs might be enormously developed to compensate for the absence of olfactory lobes in these fishes.

REFERENCES

1. Bhimachar, B. S. 1935. A study of the correlation between the feeding habits and the structure of the hind brains in the South Indian Cyprinoid fishes. *Proc. Roy. Soc.* London, **117** (B) : 258-272.
2. Bhimachar, B. S. 1937. A study of the medulla oblongata of Cyprinodont fishes with special references to their feeding habits. *Proc. Roy. Soc.* London, **123** (B): 59-68.
3. Bhimachar, B. S. 1945. Observations on the correlation between the surface living habit and the structure of the brain of the fresh water gray mullet, *Mugil corsula*. *Proc. Indian Acad. Sci.*, **21** (B): 319-327.
4. Evans, H. M. 1931. A comparative study of the brains in British Cyprinoids in relation to their habits of feeding with special reference to the anatomy of the medulla oblongata. *Proc. Roy. Soc.* London, **108** (B): 233-257.
5. Evans, H. M. 1932. Further observations on the medulla oblongata of Cyprinoids; and a comparative study of the medulla of Clupeoids and Cyprinoids with special reference to the acoustic tubercles. *Proc. Roy. Soc.* London, **117** (B): 247-280.
6. Herrick, C. J. 1905. The central gustatory paths in the brains of bony fishes. *Bull. Scit. Lab.* Denison *Univ.* **13** : 35-116.
7. Karandikar, K. R. & Thakur, S. S., 1954. *Sciaenoides brunneus* Day. Anatomy with notes on distribution and Bionomics. The *Univ. Bombay Zoological memoirs.* **3**: 71-80.
8. Mookerjee, H. K.; Ganguly, D. N. & Mookerji, P. S. 1950. Study on the structure of the brains of some Indian fishes in relation to their feeding habits. *Proc. Zool. Soc.* Bengal, **5** : 119-145.
9. Sato, M. 1937. On the barbels of Japanese sea cat fish, *Plotosus anguillaris. Sci. Rep. Tohoku Imp.* Univ. **2** : 323-332.

ABBREVIATIONS

A.TB., acoustic tubercle; C.B., cerebellum; C.H., cerebral hemisphere; FL.L., facial lobe; I. L., inferior lobe; INF., infundibulum; M.O., medulla oblongata; OL.B., olfactory bulb; O.L., olfactory lobe; OL.N., olfactory nerve; OP.CH., optic chiasma; OP.L., optic lobe; OP.N., optic nerve; PT.B., pituitary body; S.V., saccus vasculosus; V.L., vagal lobe.

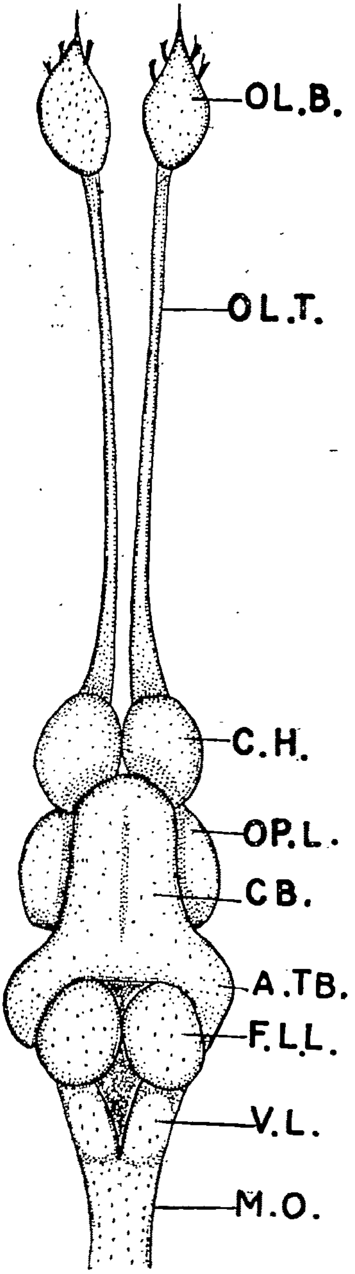

FIG.1

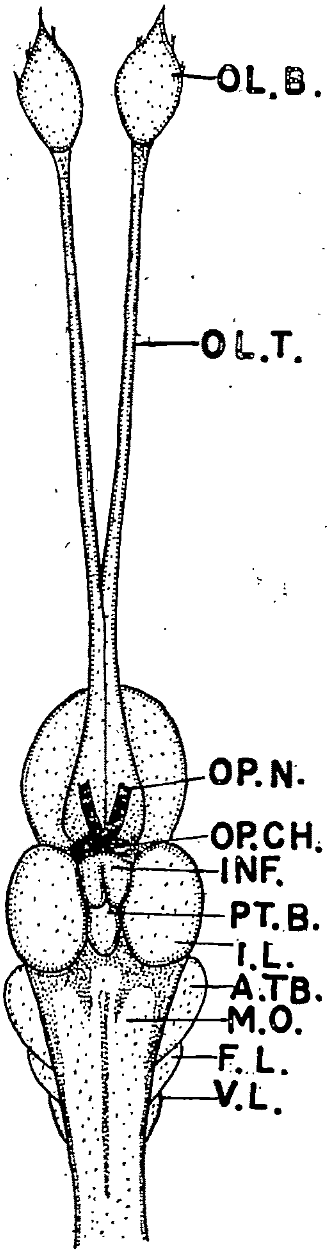

FIG.-2

Fig. 1. Brain of *Clarias batrachus* (Dorsal view)×6

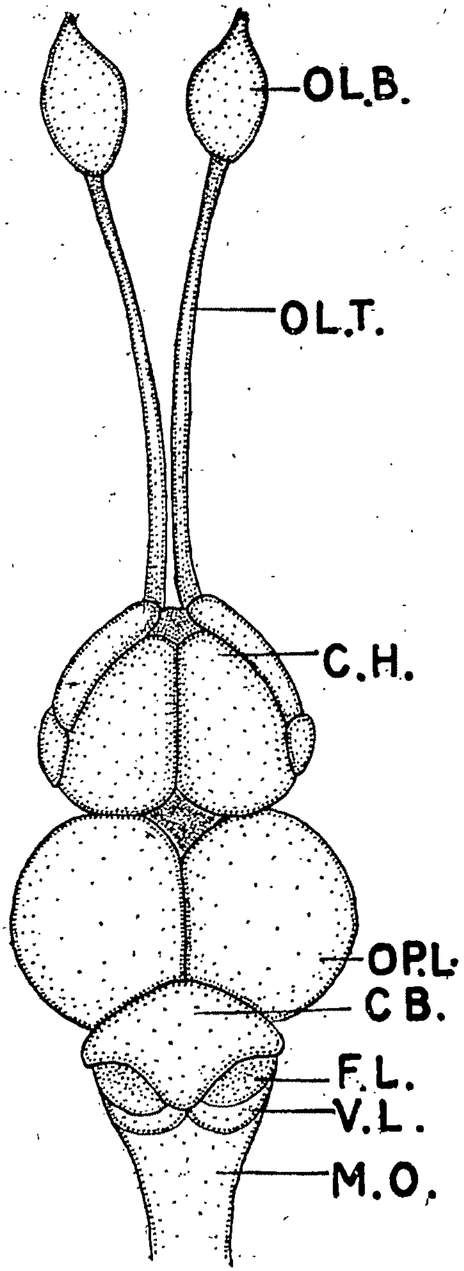

FIG.3

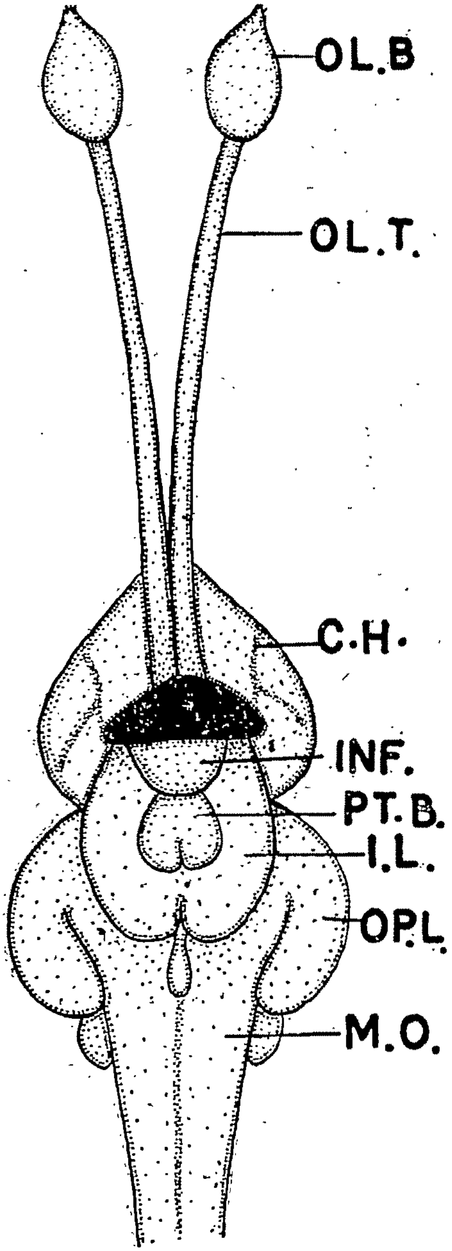

FIG. 4

Fig. 3. Brain of *Notopterus notopterus* (Dorsal view) × 6
Fig. 4. Brain of *Notopterus notopterus* (Ventral view) × 6

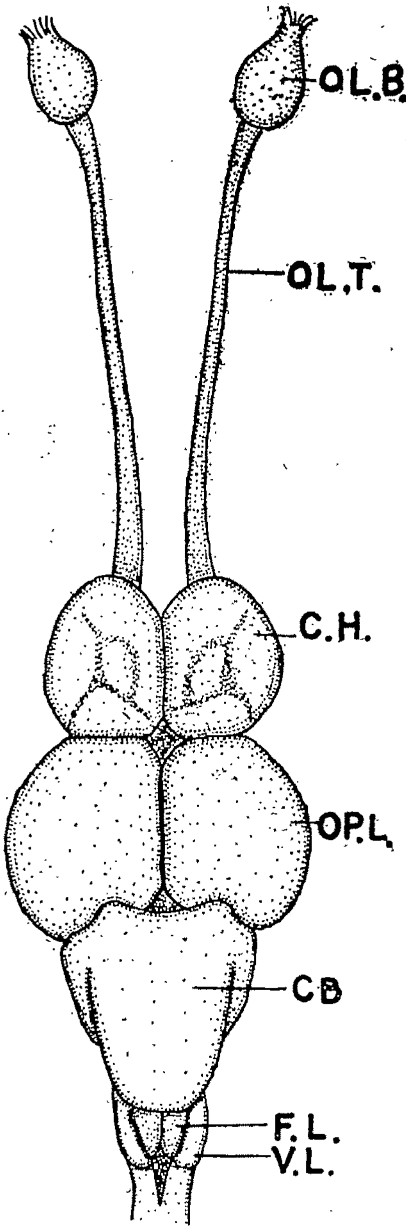

FIG. 5

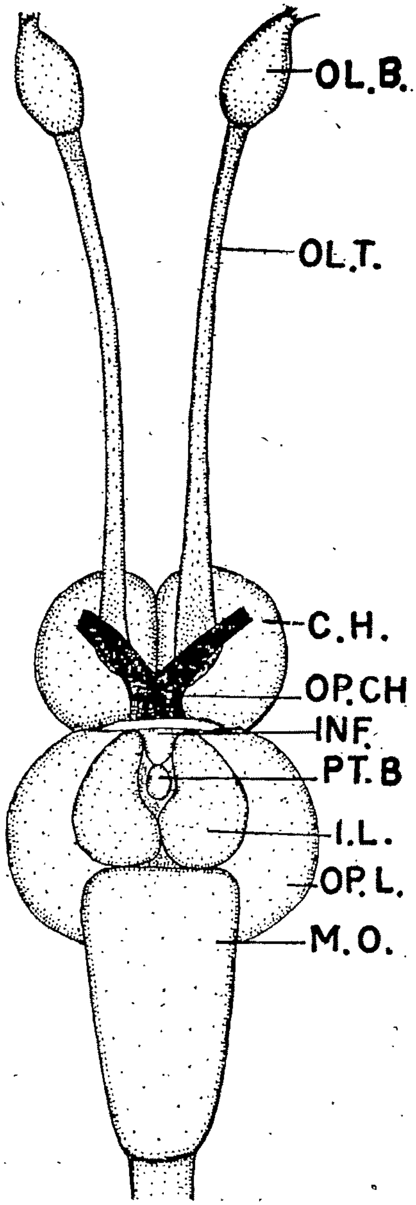

FIG. 6

Fig. 5. Brain of *Labeo gonius* (Dorsal view)×5
Fig. 6. Brain of *Labeo gonius* (Ventral view)×5

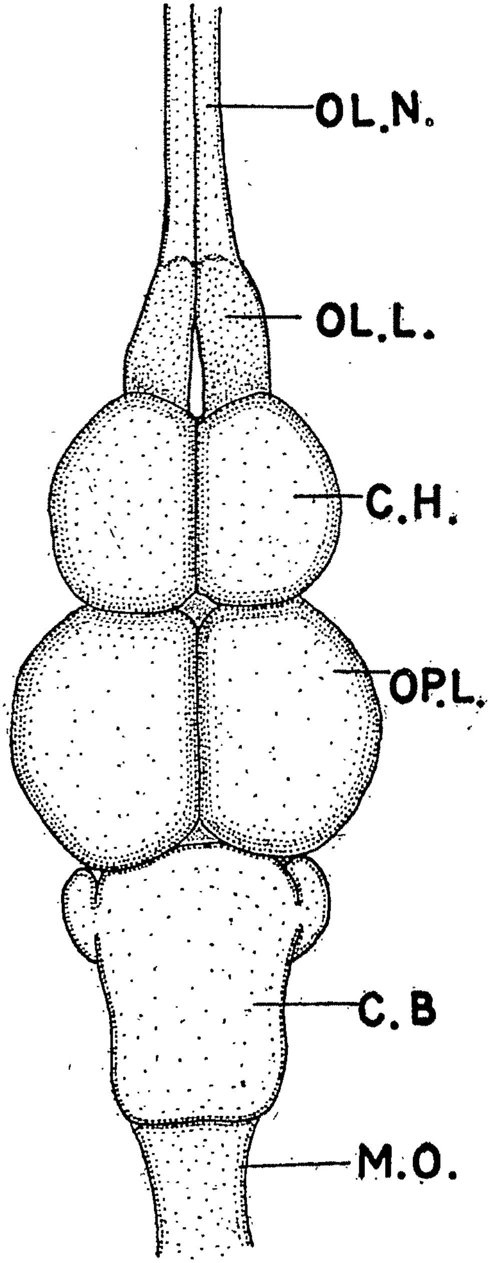

FIG. 7

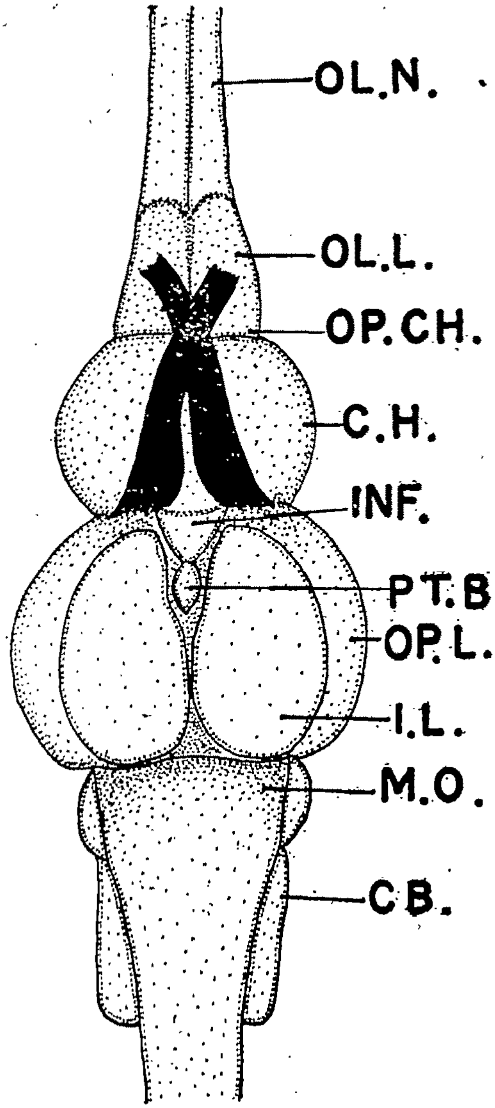

FIG. 8

Fig. 7. Brain of *Mastacembelus armatus* (Dorsal view) × 10
Fig. 8. Brain of *Mastacembelus armatus* (Ventral view) × 10.

GENERALIZED COUETTE FLOW BETWEEN TWO ROTATING POROUS CONCENTRIC CIRCULAR CYLINDERS

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Abstract

The steady flow of an incompressible fluid between two concentric rotating circular cylinders with uniform injection and suction velocities on the walls and with constant pressure gradient in the direction of the axis of the cylinder has been discussed here in the first part. In second part the flow has been considered when the outer cylinder is rotating with velocity ω and inner one is moving in the direction of the axis with a constant velocity W_0. This flow may be called generalized couette flow through the annular space between the two rotating cylinders.

Introduction

A series of papers (1 – 10) have been devoted to the laminar flow of an incompressible viscous fluid in channels and in an annulus with porous walls. But the author is here considering flow of viscous liquid through an annulus between two rotating porous coaxial cylinders with uniform injection or suction in the first part and in second part the flow has been considered when outer cylinder rotates with an angular velocity ω and the inner cylinder moves along the axis with velocity W_0.

PART I

Let us consider the steady flow of an incompressible fluid of constant viscosity between two porous concentric cylinders of radii r_1 and r_2 $(>r_1)$ rotating with angular velocities ω_1 and ω_2 respectively. Let us take a non-zero constant pressure gradient in the direction of the axis of the cylinder so that there is non zero velocity component along it.

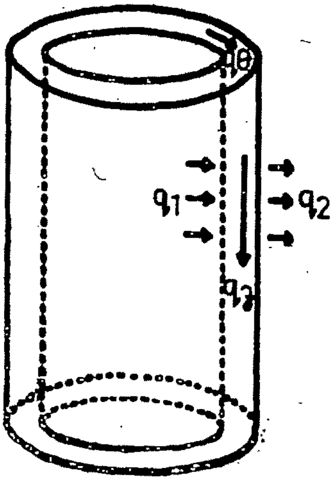

Fig. 1

Equations of Motion

If q_r, q_θ and q_z be the radial, transverse, and axial velocities respectively, ν the coefficient of kinematic viscosity and ρ the density of the fluid, we can assume

$$q_r=U(r), \quad q_\theta=V(r) \quad \text{and} \quad q_z=W(r)$$

Then the equation of continuity is,

$$\frac{\partial q_r}{\partial r}+\frac{q_r}{r}=0 \qquad ..(1)$$

and the equations of motion are

$$q_r \frac{\partial q_r}{r} - \frac{q_\theta^{\,2}}{r} = -\frac{1}{\rho}\frac{\partial p}{\partial r} + \nu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial q_r}{\partial r}\right) - \frac{q_r}{r^2}\right], \quad ..(2)$$

$$q_r \frac{\partial q_\theta}{\partial r} + \frac{q_r\, q_\theta}{r} = \nu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial q_\theta}{\partial r}\right) - \frac{q_\theta}{r^2}\right], \quad ..(3)$$

$$\text{and } q_r \frac{\partial q_z}{\partial r} = -\frac{1}{\rho}\frac{\partial p}{\partial z} + \frac{\nu}{r}\frac{\partial}{\partial r}\left(r\frac{\partial q_z}{\partial r}\right) \quad ..(4)$$

Boundary conditions are

$$\left.\begin{array}{l} \text{when } r=r_1,\ q_r=+q_1\ (q_1=+ve),\ q_\theta=r_1\,\omega_1,\ q_z=0 \\ \text{when } r=r_2,\ q_r=+q_2\ (q_2=+ve),\ q_\theta=r_2\,\omega_2,\ q_z=0 \end{array}\right\} \quad ..(5)$$

Solution

The continuity equation (1) gives,

$$q_r = \frac{A}{r} \quad ..(6)$$

From boundary conditions (5)

when $r=r_1,\ q_r=q_1$

and when $r=r_2,\ q_r=q_2$

$$\therefore\quad A = r_1\, q_1 = r_2\, q_2 \quad ..(7)$$

This implies that the suction rate at one wall depends upon the injection rate at the other wall.

Now substituting the value of q_r in (3) and putting $A+\nu=B$, we have

$$\frac{A}{r}\frac{\partial q_\theta}{\partial r} + B\frac{q_\theta}{r^2} = \frac{\nu}{r}\frac{\partial}{\partial r}\left(r\frac{\partial q_\theta}{\partial r}\right)$$

$$\text{or } A\frac{\partial q_\theta}{\partial r} + B.\frac{q_\theta}{r} = \nu\left[r\frac{\partial^2 q_\theta}{\partial r^2} + \frac{\partial q_\theta}{\partial r}\right]$$

Again putting $A-\nu=C$, we have

$$C\frac{\partial q_\theta}{\partial r} + B\frac{q_\theta}{r} = \nu r\frac{\partial^2 q_\theta}{\partial r^2}$$

Multiplying by r, we get

$$\nu r^2\frac{\partial^2 q_\theta}{\partial r^2} - Cr\frac{\partial q_\theta}{\partial r} - Bq_\theta = 0$$

Its solution is

$$q_\theta = \frac{A_1}{r} + B_1\, r^{\frac{B}{\nu}} \quad ..(8)$$

Boundary conditions are

$$\left.\begin{array}{l}\text{when } r=r_1,\ q_\theta=r_1\,\omega_1 \\ \text{when } r=r_2,\ q_\theta=r_2\,\omega_2\end{array}\right\} \qquad ..(9)$$

$$\therefore\ r_1\,\omega_1=\frac{A_1}{r_1}+B_1\ r_1^{B/\nu}$$

and
$$r_2\,\omega_2=\frac{A_1}{r_2}+B_1\,r_2^{\frac{B}{\nu}}$$

From these equations A_1 and B_1 can be easily obtained and thus q_θ is known. Substituting the values of q_r and q_θ in equation (2) we have

$$-\frac{A^2}{r^3}+\frac{1}{r}\left[\frac{A_1}{r}+B_1 r^{\frac{B}{\nu}}\right]^2=-\frac{1}{\rho}\frac{\partial p}{\partial r} \qquad ..(10)$$

From this equation it is clear that

$$\frac{\partial p}{\partial r}=f(r)$$

$$\therefore\quad p=\phi(r)+\psi(z)$$

$$\therefore\quad \frac{\partial p}{\partial z}=\psi'(z)$$

But it will satisfy equation (4) only and only when $\psi'(z)=$ constant

$$\therefore\quad \frac{\partial p}{\partial z}=\text{constant}=P \text{ (say)} \qquad ..(11)$$

From equation (4) putting the values of q_r and $\frac{\partial p}{\partial z}$, we have

$$\frac{A}{r}\frac{\partial q_z}{\partial r}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+\frac{\nu}{r}\left\{r\frac{\partial^2 q_z}{\partial r^2}+\frac{\partial q_z}{\partial r}\right\}$$

$$\text{or } \frac{C}{r}\frac{\partial q_z}{\partial r}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+\nu\frac{\partial^2 q_z}{\partial r^2}$$

$$\text{or } \frac{\partial^2 q_z}{\partial r^2}-\frac{C}{\nu}\frac{1}{r}\frac{\partial q_z}{\partial r}=\frac{P}{\nu\rho}$$

$$\therefore\ \frac{1}{r^{C/\nu}}\frac{\partial q_z}{\partial r}=\frac{P}{\nu\rho}\int\frac{1}{r^{C/\nu}}dr+\lambda=\frac{P}{\nu\rho}\frac{1}{\frac{C-\nu}{r^\nu}}\left(-\frac{C}{\nu}+1\right)+\lambda$$

where λ is constant of integration,

$$\text{or } \frac{\partial q_z}{\partial r}=\frac{P}{\nu\rho}\frac{1}{\frac{C}{r^\nu}-1}\,r^{C/\nu}\cdot\frac{\nu}{(\nu-C)}+\lambda\,r^{C/\nu}$$

$$= \frac{P}{\rho\,(\nu - C)}\, r + \lambda r^{C/\nu}.$$

$$\therefore \quad qz = \frac{P}{2\rho\,(\nu - C)}\, r^2 + \frac{\lambda\nu}{C+\nu}\, r^{C/\nu + 1} + \lambda',$$

Boundary conditions are:

when $r = r_1, \quad q_z = 0$

when $r = r_2, \quad q_z = 0$

$$\left.\begin{aligned} \therefore \quad 0 &= \frac{P}{2\rho\,(\nu - C)}\, r_1^2 + \frac{\lambda\nu}{C+\nu}\, r_1^{C/\nu + 1} + \lambda' \\ \text{and} \quad 0 &= \frac{P}{2\rho\,(\nu - C)}\, r_2^2 + \frac{\lambda\nu}{C+\nu}\, r_2^{C/\nu + 1} + \lambda' \end{aligned}\right\} \quad ..(12)$$

From these equations λ and λ' can be determined easily and thus q_z is also known.

PART II

EQUATIONS OF MOTION

Consider the case when constant pressure gradient acts in the direction of the axis, the outer cylinder rotates with angular velocity ω and the inner cylinder moves with velocity W_0 along the axis.

Under these circumstances, we can assume

$$q_r = 0, \quad q_\theta = V(r), \quad q_z = W(r).$$

Then the equations of motion are

$$\frac{q_\theta^2}{r} = \frac{1}{\rho} \frac{\partial p}{\partial r} \quad ..(1)$$

$$\frac{\partial^2 q_\theta}{\partial r^2} + \frac{1}{r} \frac{\partial q_\theta}{\partial r} - \frac{1}{r^2}\, q_\theta = 0 \quad ..(2)$$

$$\text{and } \nu \left(\frac{\partial^2 q_z}{\partial r^2} + \frac{1}{r} \frac{\partial q_z}{\partial r} \right) = \frac{P}{\rho} \quad ..(3)$$

We have also the equation of continuity,

$$\frac{\partial q_r}{\partial r} + \frac{q_r}{r} + \frac{1}{r} \frac{\partial q_\theta}{\partial \theta} + \frac{\partial q_z}{\partial z} = 0 \quad ..(4)$$

which is automatically satisfied.

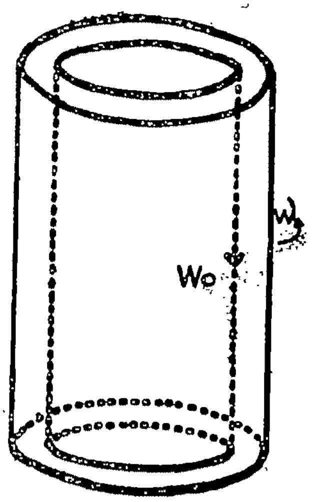

Fig. 2.

The boundary conditions are:

$$\left.\begin{aligned} &\text{when } r = r_1, \; q_\theta = 0, \quad q_z = W_0 \\ &\text{when } r = r_2, \; q_\theta = r_2\,\omega, \; q_z = 0 \end{aligned}\right\} \quad ..(5)$$

SOLUTION

From equation (2) it is apparent that the most general form of q_θ which is compatible with $\nu \neq 0$, is

$$q_\theta = A' r + \frac{B'}{r} \quad ..(6)$$

Boundary conditions are :

$$\left.\begin{aligned} &\text{when } r=r_1,\ q_\theta=0, \\ &\text{and when } r=r_2,\ q_\theta=r_2\omega, \end{aligned}\right\}$$

$$\left.\begin{aligned} \therefore\quad 0 &= A' r_1 + \frac{B'}{r_1} \\ \text{and}\quad r_2\,\omega &= A' r_2 + \frac{B'}{r_2} \end{aligned}\right\} \quad ..(7)$$

From these equations A′ and B′ may be easily obtained and thus

$$q_\theta = \frac{\omega r_2^2}{r_2^2 - r_1^2}\, r - \frac{\omega r_1^2 r_2^2}{r_2^2 - r_1^2}\, \frac{1}{r} \quad ..(8)$$

The pressure distribution is then found from (1) by direct integration.

The solution of equation (3) is

$$q_z = C' + D' \log r + \frac{P}{4\rho\nu}\, r^2 \quad ..(9)$$

where C′ and D′ are constants of integration.

Boundary conditions are :

$$\left.\begin{aligned} &\text{when } r=r_1,\ q_z=W_0 \\ &\text{when } r=r_2,\ q_z=0 \end{aligned}\right\} \quad ..(10)$$

$$\left.\begin{aligned} \therefore\quad W_0 &= C' + D' \log r_1 + \frac{P}{4\rho\nu}\, r_1^2 \\ \text{and}\quad 0 &= C' + D' \log r_2 + \frac{P}{4\rho\nu}\, r_2^2 \end{aligned}\right\} \quad ..(11)$$

From these equations C′ and D′ may be determined and thus q_z is also known.

ACKNOWLEDGEMENTS

I thank Dr. J. P. Agarwal for his help in the preparation of the paper. I am also grateful to Dr. M. Ray, D. Sc., F. N. I. for his constant encouragement.

REFERENCES

1. Berman, A. S. 1953. *J. Appl. Phys.*, **24**: 1232.
2. Berman, A. S. 1958. *J. Appl. Phys.*, **29**: 71.
3. Das, S.P. 1966. Archiwun Mechanilei Stosowanej **1**: 18.
4. Hasimoto, H. 1957. J. *Phys. Soc.*, Japan **12**: 68.
5. Nanda, R.S. 1958. *J. Phys. Soc.*, Japan **13**: 748.
6. Satya Prakash, 1967. *J. Birla Inst. Tech. & Sci.*, **1**: (1).
7. Sellars, J. R. 1955. *J. Appl. Phys.*, **26**: 489.
8. Turton, F. J. 1941. Dec. *Phil. Mag.*, **32** (sec. 7) No. 215.
9. White, Barfield & Goglia, 1958. *Trans. Asme J. Appl. Mechs.*, **25**: 613.
10. Yuan, S.W. 1956. *J. Appl. Phys.*, **27**: 267.

STUDIES ON THE FACTORS AFFECTING LARGE SCALE PRODUCTION STORAGE AND PACKAGING OF BUTTER FROM BUFFALO CREAM COLLECTED UNDER COMMERCIAL CONDITIONS

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The thesis embodies the results of an investigation on the factory method of buttermaking exclusively from buffalo milk cream. The study was undertaken in the context of current industrialization of dairying in India, wherein diversion of increasing amounts of buffalo milk from milk pockets and seasonal surpluses is contemplated for production of table butter through the organization of rural creameries. The objects of the study were : (*i*) the factors involved in manufacture, (*ii*) packaging, (*iii*) storage and grading and (*iv*) rheological aspects of factory butter made from cream separated from collected village milk. The data have been grouped according to manufacturing technique, storage studies, biochemical aspects of butter grading and rheological properties of butter.

I. The fat recovered in butter (98·89%) from 35% cream was significantly higher than that from 50% fat cream (98·45%). Among the two different creams viz., 35 and 50%; the high fat cream was observed to give rise to mechanical difficulties during buttermaking specially during pumping from the ageing vat to the churn. The mechanical loss of fat in 35% cream was (100-98·89+0·75)=0·36%, whereas the same from 50% cream was (100−98·45+0·80)=0·75%. The observations made on overrun suggest the suitability of 35% cream as the overrun remained nearer to 20%.

Reduction in the acidity of sour cream with sodium-bi-carbonate to 0·10-0·15 per cent (lactic) seems to be satisfactory to enable exhaustive churning. The acidification of neutralised cream was found to reduce the fat losses in buttermilk.

Higher temperature of pasteurization (170°F for 10 minutes) was found to lessen the recovery of fat in butter on account of increased fat losses in buttermilk.

Rapid cooling of cream to 40°F. and ageing for 6 hours was found to give equal recovery of fat in butter against that of slow cooling to 50°F and ageing for 12 hours. Low temperature cooling of cream was found to impart sticky tendency to the butter and the butter did not readily accept the 'make-up' moisture.

Unwashed butter had on an average 1·20% curd against its washed counterpart with 0·74%. This indicates that nearly 40% of the curd in butter was reduced by washing. The unaccounted mechanical losses of fat in unwashed butter were 100—(98·65+0·85)=0·50%, whereas for washed butter the same were 100—(98·59+0·82)=0·59%. Elimination of factory routine of washing procedure can avoid about 0·10% of fat loss.

Comparative study of the metal churn versus wooden churn revealed that the recovery of fat in butter and losses of fat in buttermilk were of the same order. Wooden churn showed comparatively very low initial moisture test (10·8%) than metal churn (13·7%). Wooden churn gave slightly soft-bodied butter, but the butter was of finer texture and with a characteristic sheen on the surface. The metal churn took less churning time though the time for working was more with the wooden churn.

II. Butter made from fresh farm cream had a 'shelf-life' of 3 months at —10°F and 3 weeks at 40°F whereas the butter from village cream retained its initial quality upto 2 months at —10°F and for 2 weeks at 40°F.

High acid cream neutralized to an acidity of 0·10-0·15% (lactic) yielded butter with similar 'shelf-life' as that of the butter from fresh cream.

High-acid cream (village), neutralized and acidified with starter (for flavour improvement) did not show keeping quality of more than 60 days at —10°F as judged by development of Peroxide value and loss in flavour.

Butter made with the addition of fat residues (from earlier churnings) to cream had low keeping quality. Such butter should be intended for immediate sale.

The effect of higher temperature (170°F for 10 minutes) of pasteurization in retardation of the development of peroxide value was significant for the period between 90 to 150 days at —10°F.

Washed and unwashed butters showed similar trend in the development of peroxide value but the degradation in organoleptic quality was slow in the unwashed butter than in the washed butter. Under controlled methods of production and processing of raw material, the washing procedure can be safely eliminated when the butter is made from fresh cream.

Serum pH of butter made from different types of cream averaged:

Farm fresh—6·73; Village fresh —6·68; Farm and Village, aged, neutralized—6·6; Village neutralized acidified —5·4.

The coefficient of regression (byx) for development of peroxide value at —10°F for butter made from different types of cream was:

Farm fresh—0·0010; Village fresh —0·0026; Farm neutralized 0·0013; Village neutralized —0·0020; Farm pasteurized (170°F) —0·0940; Village pasteurized (170°F) —0·1044; Farm unwashed —0·0013; Village unwashed-

0·0014; Village aged, neutralized and acidified-0·0018; Cream with added fat residues —0·0022.

The coefficient of regression (byx) for the development of peroxide value at 40°F for butter made from different types of cream was :—

Farm fresh —0·0025; Village fresh—0·0037; Farm neutralizied—0·0030; Village neutralized-0·0042; Farm pasteurized (170°F) —0·0020; Village pasteurized (170°F) —0·0027; Farm unwashed—0·0033; Village unwashed—0·0040; Village, aged neutralized and acidified—0·0038; Cream with added fat residues —0·0065.

The analysis of covariance of the regression co-efficients (byx) at two different storage temperatures indicated that the byx values for various types of butter were heterogeneous. This indicated that the development of peroxide value in butter made from various types of cream and from various treatments of cream, was significantly different.

III. An attempt was made to find out the applicability of WIA (water insoluble acid)—number for indexing the quality of buffalo cream. Initial WIA number of cream ranged between 32·0 to 101·2. Cream samples scoring 92 had WIA number between 32·0 and 50·0. Quality estimation of cream stored at room temperature (70-90°F) by WIA test corresponding to organoleptic score was satisfactory in the first 3 days of storage. Cream stored at refrigerator temperature (40°F) showed a lower range of WIA (48·3-112·0). The organoleptic grading of cream was also found to correspond with WIA test at low temperature storage.

Low WIA values of butter were found to correspond with high table quality of butter. Most of the samples with high organoleptic grade (score 91-92) had WIA values between 41·0—82·3.

The method of indexing the quality of butter with the WIA number and the yeast and mold count was employed successfully. Low yeast and mold count of butter was found to correspond with low WIA value of the butter.

IV. Rheological studies on the fresh and stored butter were carried out. Evidence is presented which shows that although rapid cooling of cream to low temperature results in apparently harder butter, considerable amount of liquid fat is left in the butter which is freely liberated at higher temperature.

The use of additives to enhance the initial hardness of butter and the stability (of hardness) during storage was tried out. Gelatin and Tween-80 were found to increase the hardness. Tween-80 was found to decrease the Oiling-off from the canned butter, as well as from the butter wrapped in vegetable parchment paper.

Abstract of Theses

A CASE OF TRUE-BRANCHING IN THE GENUS *NOSTOC*-VAUCH.[1]

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INTRODUCTION

The author, while studying the "Algal Flora of Vindhyan Formations of Mirzapur District, U.P.", came across a remarkable form of *Nostoc*, exhibiting true branching. It may be mentioned that a very vague reference to a similar type of branching has already been made by Geitler and Rüttner (1935) in an unidentified material of *Nostoc* described from Sunda Islands.

MATERIAL AND METHODS

The material on which the present investigation is based was collected from "Windhyan Fall," which is situated at a distance of 10 miles from Mirzapur city, in the month of October, 1947, and again in the same month, in 1948. The alga was found growing among the mosses on a moist slopy rock and was preserved in 4% formalin at the spot.

General vegetative features of the alga

The mucilaginous balls (Fig. 1) of the alga, which are found gregariously, measure from 60·600μ in diameter. As the ball increases in size it flattens to form lobed expanses as in *Nostoc linckia* and *Nostoc Commune* etc The much contorted trichomes (Fig 2) within the balls are irregularly dispersed. The cells are barrel-shaped, and constricted at the septa. They measure from 4·4 – 5·4μ in breadth and 5·4 – 7·7μ in length.

The position of heterocysts is variable. Generally it is intercalary (Fig. 3), but in some cases terminal (Fig. 4) and lateral (Fig. 5) ones are also met with. The intercalary heterocysts are either quadratic or slightly longer than broad. The inner wall of the intercalary heterocyst, after a long immersion in chloro-zinc-iodide, gives the violet reaction of cellulose (Cf. Geitler, 1932) and pores stand out clearly. The outer wall of these heterocysts fails to give the reaction of pectin with ruthenium red. The terminal heterocysts (Fig. 4), which are formed only at the tips of the branches, are generally spherical and are developed from ordinary vegetative cells by the usual method (Cf. Bhâradwâja, 1933 and Fritsch, 1945, pp. 796-800). The origin of lateral heterocysts (Fig. 5) could not be ascertained. However, they appear degenerating as their walls do not take stain with chloro-zinc-iodide. The heterocysts generally measure from 5·4-6·3μ in breadth and 5·4-7·2μ in length and are provided with two-layered wall. Germination of the heterocysts (Figs. 6 & 7) has also been observed as in

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[1] From a dessertation submitted to the Department of Botany, Banaras Hindu University in partial fulfilment of the requirements for the degree of Master of Science.

Nostoc Commune, *Nostoc muscorum* and *Nostoc microscopicum* previously recorded by Fritsch, 1945.

Reproduction :

Even when the colonies are very young and small some of the vegetative cells of the trichome become larger and are filled with highly granular contents. These cells never get differentiated into individual akinetes. On the other hand, they sooner or later get enclosed by a mucilaginous wall (Fig. 8). and become independent in due course. There has been a good deal of difficulty in interpreting the structure in question. According to the Orthodox opinion these reproductive bodies have been described as hormogones (Cf. Fritsch, 1945, p. 804). Hormogones, however, are formed without the differentiation of the cells and they are provided only with delicate mucilage-envelope, but the reproductive bodies in this particular case are formed from the differentiated cells and are closed at both the ends by a thick stratified mucilaginous wall (Fig. 8) and this recalls the hormocyst formation of *Scytonematacea* and *Stigonematacere*. In writer's opinion similar structures are also met with in *Nostoc punctiforme* and *Nostoc Commune* (Cf. Geitler 1932, p. 635 and 646) which perhaps might have been misinterpreted as hormogones by previous workers. The liberation of these fully-formed hormocyst, is brought about by the degeneration of the heterocysts and sterile cells between them.

Again, some of the differentiated cells described above, which are destined to give rise to the hormocysts before being enclosed by a wall germinate *in situ* and row of paired cells are formed (Fig. 9). Mostly these cells divide transversely but some of them which do not find space to do so bulge out laterally (Fig. 9) as in *Nostoc Commune* (Cf. Geitler, 1932, p. 64, Fig. 53) and get partitioned by a longitudinal wall (Fig. 10). The upper daughter cell divides and redivides transversely and ultimately forms a branch (Fig. 11 and 12). In this way a true-branch is formed.

Systematic Position of the Alga :

The present form, in possessing a colony of gelatinous envelope of firm consistency and well-defined contorted trichomes, and in the formation of so-called hormogonia (hormocysts) etc., resembles *Nostoc*, particularly with *Nostoc Commune* in the tendency of the mucilaginous colonies to flatten, in the dimensions of the trichomes and heterocysts and in the absence of akinetes, but it differs from the same in the presence of true-branches (Cf. Geitler and Rüttner, 1935, pp. 454-455, Fig. 83). However, true-branching is so rare that the writer does not venture to raise the present alga to the status of a new species at this stage, but prefers to make it a new variety of *Nostoc Commune* to be named as *Nostoc Commune* Vauch. Var *ramosa* var. nov. till life history has been followed in culture.

Diagnosis of the new variety

Nostoc Commune Vauch. var. *ramosa* var. nov. (Fig. 1-12).

Plant mass mucilaginous, colonies spherical, violet in colour, trichomes packed or scattered within the mucilaginous envelope. Cells barrel-shaped, constricted at the septa, measuring 4·4-5·4μ in breadth and 5·4-7·7μ in length, end cells conical with a rounded apex; heterocysts intercalary terminal or lateral, measuring 5·4-6·3μ in breadth and 5·4-7·2μ in length. Akinetes absent; reproduction by hormocysts. Formation of true-branches is an unique feature.

Habitat—On moist rock among mosses, Windhayan Fall Mirzapur District, October, 1947 and 1948.

DISCUSSION

In a number of contributions Fritsch (1942, 1944, 1945) distinguishes between the Orders Nostocales and Stigonematales of class cyanophyceae on the basis of their mode of branching as well as in some other characters. The former order is characterized by the exclusive development of false-branches, while the latter by the prevalent true-branching. The present form is of special interest in this connection, since it is undoubtedly a member of the order Nostocales and still possesses true-branches. The true-branches, however, are rare and in case they prove to be of common occurrence, the criterian of distinction between the above orders will have to be revised.

SUMMARY

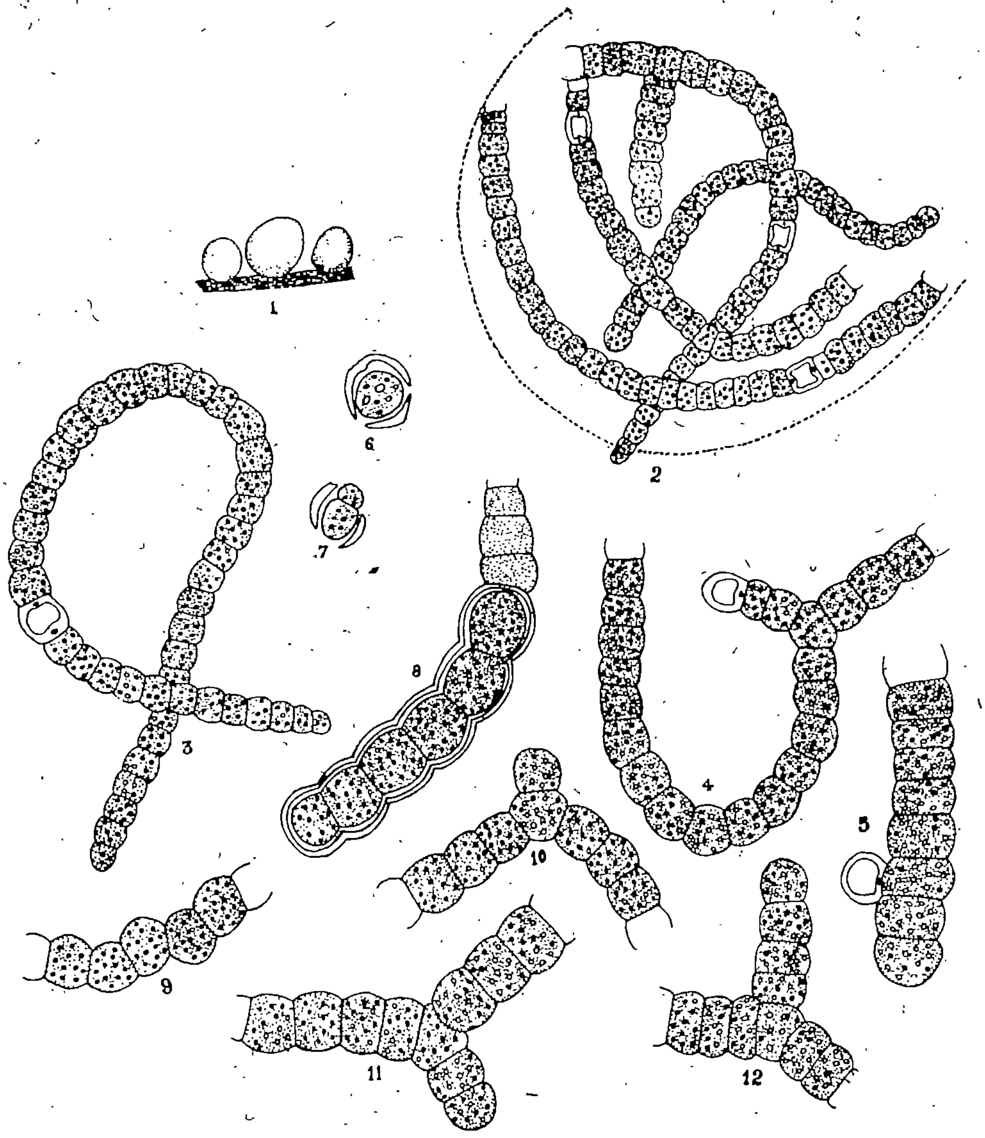
A new variety of *Nostoc Commune* Vauch. var. *ramosa* var. nov. has been described in detail from Windhyan Fall of Mirzapur District. The chief interest in the new variety lies in the occurrence of true branching, the formation and development of which has been studied. Besides, structures comparable to hormocysts have also been investigated.

ACKNOWLEDGEMENTS

The author expresses his great indebtedness to late Prof. Dr. Y. Bhâradwâja, M. Sc., Ph. D. (London), F.L.S., F.N.I. and Dr. R.N. Singh for their kind guidance and criticism throughout the course of this investigation.

LITERATURE CITED

1. Bhâradwâja, Y. 1933. Contribution to our knowledge of the Myxophyceae of India. *Ann. Bot.*, **XLVII**: 117.
2. Fritsch, F.E. 1942. The Interrelations and Classification of the Myxophyceae. (Cyanophyceae) *New Phytol.*, **41**: 134.
3. *Fritsch*, F.E. 1944. Present-day Classification of Algae. *Bot. Rev.*, **10**: 233-277.
4. *Fritsch*, F.E. 1945. The Structure and Reproduction of the Algae. II. Cambridge University Press, pp. 939.
5. Geitler, L. 1932. Cyanophyceae, in Rabenhorst *Kryptogamen Flora von Europa*, **XI**, Leipzig.
6. Geitler, L. & Rüttner, F. 1935. "Die Cyanophyceea der Deütschen Limnologischen Sunda Expedition, ihre Morphologie, Systematik und Oeklogie. I-II". Arch. *Hydrobiol.* Suppl. Bd. **14**: 308.



EXPLANATION OF FIGURES

Fig. 1. *Nostoc* balls, showing the habit.
Fig. 2. A crushed colony, showing the contorted trichomes within the common sheath, X 400.
Fig. 3. Trichome, showing intercalary heterocyst. X 520.
Fig. 4. Trichome, showing terminal heterocyst. X 520.
Fig. 5. Trichome, showing lateral heterocyst X 520.
Figs. 6,7 Germination-stages of heterocysts. X 520.
Fig. 8. Development of hormocyst. X 520.
Fig. 9. Paired-cells of a trichome, X 520.
Figs. 10-12. Stages in true-branch formation. X 520.

THE FISH CURING YARDS IN VISAKHAPATNAM DISTRICT*

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The fish curing yards were first established in Madras in 1874 and their number has been increasing ever since. In 1948, there were 187 fish curing yards along both the coasts of India. Of these, 163 were on the West coast and only 24 on the East coast. Of the West coast yards, 96 were operated by the Bombay Government, while 53 and 14 yards were under the charge of the Governments of Madras and Travancore-Cochin, respectively. The fish-curing yards in Orissa which were previously managed by Government, have been handed over to fishermen's Co-operative Societies. Bombay has no yards north of Ratnagiri District and there are no fish curing yards in Saurastra and Cutch.

At present in Visakhapatnam district there are three fish curing yards, which are located in Bhimilipatnam, Mukkam and Mantigomari peta (M.G. Peta).

In the absence of adequate supplies of ice and rapid transport, a large quantity of surplus catches from the sea is dried and cured all along the coast usually under conditions that are not altogether hygienic or economical. It is estimated that nearly 50% of marine fish catches are at present being processed resulting in products that are often of poor quality. Curing of fresh water fish is not practised on any large scale.

Different methods of fish curing are employed in this district. The main principle involved in almost all the methods is the removal of waters from fish muscle, partly by osmosis, as a result of the application of salt, and partly by drying. The addition of indigenous preservatives and spices in the cure or pickle further enhances the keeping qualities of the preserved fish and provides an agreeable flavour. The following methods of fish curing are generally employed.

(1) *Sundrying*

The fish are dried on the beach on mats for 2 or 3 days with an occasional turning over. By far the largest quantities of fish are cured by this method. Comparatively small and lean kinds of fishes like Ribbon fish and prawns are cured in this way. The progress even in the mode of drying has come from those regions.

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* This is a chapter of the Thesis submitted to and approved by the University of Agra for the degree of M. Sc. in Zoology in the year 1963.

1. Complete drying is one of the best as well as the simplest methods of preserving food products. Bacteria cannot act in the absence of moisture and in the tropics, the powerful sun is always at hand to dry without cost, salt is used both as an antiseptic and to hasten the drying of tissues.

2. In drying a smaller amount of salt is needed. It is a matter of great importance where salt is very expensive.

3. The nutritive value is mostly retained by simple drying whereas much is lost in heavily salted goods through the extraction by the salt nutritive funds from the cells. Extreme drying reduces digestibility and consequently its nutrient quality.

4. By the great reductions in the weight, transport difficulties and charges are reduced to a minimum, a most important point where comunications are defective and journeys lengthy.

5. No elaborate packing is required beyond simple matting and this again lessens cost as well as weight for transport.

6. No expensive machinery or plant is required.

7. The result is that sundried fish is probably the cheapest of all preserved goods.

Bacteria can act only in the presence of moisture. If it is absent the bacteria is incapable of action or reproduction so that putrification ceases.

(2) *Salt curing in pits*

The fish are rubbed with salt and piled in pits, lined and covered with leaves. After stipulated period the fish is removed and dried in the sun. A similar pit-curing method is also employed in other areas of Andhra Pradesh. The product is very inferior, but finds a ready market among the poor classes.

(3) *Smoking*

No regular smoking of fish is done at Visakhapatnam District.

From the above description of methods employed for curing fish in Visakhapatnam District, it will be observed that there is a wide range in the degree of drying and intensity of salting. As a rule, the quantity of salt used is inadequate and the product generally liable to insect attack and putrification.

In order to improve the quality of cured fish, the Department of State Fisheries have established fish curing yards at principal fish assembly centres like Bhimunipatnam, Mukkam and M. G. Peta. In these yards facilities are provided for curing fish under hygienic conditions. In order to induce the fishermen to bring their fish into the yards and cure it under proper supervision, the fishermen at Visakhapatnam District are, however, receiving the supply of salt at concessional rates.

Statement No. 1

Statement showing the Fish Curing Yard Transactions at Visakhapatnam District During 1961-1962

Name of the fish curing yard	Fish let in (in mds)	Fish let out (in mds)	Salt purchased (in mds)	Salt issued (in mds)	Sale proceeds (in Rs.)	No. of fish curers
1. Bhimunipatnam	2960·31	1709·00	340·00	359·10	143·70	605
2. M. G. Peta	4684·20	2522·20	478·00	571·23	228·63	1219
3. Mukkam	6734·30	3932·34	790·00	821·05	328·45	1658

From the available information it appears during the year 1961-62 14,388·01 maunds of fish is brought into fish curing yards, but considerable quantities are also cured outside the yards of this district. Every effort is being made by the Department of the State Fisheries concerned to induce the fishermen to improve the quality of cured products, a large proportion of which is exported to the neighbouring villages of Visakhapatnam.

ACKNOWLEDGEMENTS

We are indebted to Dr. R. D. Saksena, Professor and Head of the Department of Zoology, R.B.S. College, Agra without whose co-operation this work could not have been carried out.

REFERENCES

1. Dodd, N. E. 1951. Recent progress in the curing of Fisheries Products. *F A. O. Publication.* 4 (5).
2. Government of India 1941. Agricultural marketing in India Preliminary guide to Indian Fish and Fisheries, Methods of Fishing and curing *Mark. Ser.* No. 24.

INVESTIGATIONS ON THE MANURIAL PRACTICES AFFECTING GROWTH, YIELD AND QUALITY OF RABI FODDERS GROWN PURE AND MIXED[1]

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Of all the countries in the world, India possesses the largest livestock population (336·4 million, India 1965) but of poor health. The production of fodder and the feeds available per capita are very low. Banerji (1951) has stated that over 90 per cent of our cattle subsist on the degraded forest grasslands. Likewise Semple (1952) has quoted that 75 per cent of our cattle get their food supplies from crop residues.

Over a large part of the country, the crop rotations allow little provision for good quality fodder and mostly the straw and *Karbi* of the grain crops and the grasses of degraded forest grasslands form the main part of the bulky ration. Recently ever-increasing demand of food in the country has led the farmers to grow grain and other food crops even on the grasslands and pasture areas. This has further deteriorated the position of fodder supply and consequently the health of our cattle at large. Indeed the fodder shortage is the problem of the day which threatens our nation and engages the attention of both the public and scientists alike.

While considering the above problem one cannot overlook the fact that the area under fodder crops is very insufficient (5·29 per cent of the cultivated area, I. C. A. R. 1961) and because of competition with cash crops, which are more paying to the cultivators and also in view of the present food crisis, further increase of the area under fodder may not be advisable. The possibilities to improve the fodder supply from the area already under fodders are to be sought therefore. It is felt that while evolution and production of high yielding varieties by plant breeding methods is a time taking process, providing better conditions for plant growth through agronomical practices is possible and can be quickly complied with.

Keeping in view the above considerations, a field experiment entitled "Investigations on the manurial practices affecting growth, yield and quality of *rabi* fodders grown pure and mixed" was conducted during three consecutive *rabi* (winter) seasons, 1960-61 to 1962-63, on the same layout in field No. B-13, at Raja Balwant Singh College, Agricultural Research Station, Bichpuri, Agra (India). Five treatments of crops and their mixtures viz. berseem, oats, senji, oat+berseem and oat+senji and four manurial treatments viz. control,

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[1] Abstract of thesis on which Ph.D. degree has been awarded by the Agra University.

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44·8 kg. N/ha., 44·8 kg. P_2O_5/ha and 44·8 kg. N + 44·8 kg. P_2O_5/ha. were tried. In all, there were twenty treatment combinations and these were replicated four times in a 'strip plot' design.

Oats, veriety Kanpur 71, at the rate of 78·4 kg/ha., berseem (local) and senji (FOS-I) each at the rate of 28 kg per hectare and the crop mixtures, prepared with 50 per cent seed rate of each component, were sown broadcast. Nitrogen through ammonium sulphate was broadcasted and phosphate through single superphosphate was drilled day before sowing of the crops in each year.

Oats and senji being short duration crops gave only three cuttings while in case of berseem the fourth cutting was also possible. The results of this work are summarised below:—

1. The maximum production was obtained by the oat-berseem mixture. The next best crop was berseem pure in this respect. The yield of senji pure was the lowest.

2. The height of legumes was not affected much when they were grown either pure or mixed with oats, while fresh and dry weights of legumes were slightly decreased due to the association effect. The growth of oats in terms of height, fresh and dry weights was much improved when it was grown in association with legumes and more so with berseem.

3. Survival percentage of oat-berseem mixture was consistently higher at almost all the stages as compared to that of other forages.

4. Growing of oat-berseem forage resulted in the production of maximum starch equivalent per hectare which was significantly greater than oats, senji and berseem in the first year and oats and senji in the second year.

5. Widest nutritive ratio was inherent in the produce of oat-forage and the narrowest in the yield of senji forage. Berseem plants ranged next to senji. Oat-berseem and oat-senji mixtures between which the difference was non-significant attained intermediary values. From the point of view of balanced feed neither too wide nor too narrow a N. R. can be considered as reasonable, and a moderate ratio may bring about a compromise. Growing of oat-berseem forage which possessed a moderate N. R. (1:4 to 5) was considered satisfactory also due to its high capacity of crude protein production.

Senji pure analysed the highest crude protein content. This was followed by the crop of pure berseem. Thus both these crops proved significantly superior to pure oats or its mixtures with respect to protein content. The forage mixtures which did not differ significantly from each other were significantly better in protein content than oats.

6. Oat-berseem proved to be the best mixture with respect to crude fat production per hectare. However, the variations between oat-berseem and oat-senji mixture were not much. As regards per cent content of crude fat, senji

pure contained the maximum. Oats pure and its mixture either with berseem or senji did not differ much from one another with respect to this ingredient, but these forages have significantly higher fat content than berseem forage.

7. Mineral matter production per hectare by oat-berseem, oat-senji and berseem forage was found to be better than that under oat and senji crops. Regarding the mineral matter content in forages berseem pure followed by senji pure showed a significant improvement over oats pure and its mixtures in the first year. The same trend was observed in the second year but the results did not differ significantly.

8. When fibre percentage in total forage was taken into consideration, oats pure was followed by oat+senji, oat+berseem, berseem pure and senji pure in a descending order during first year. In the second year oat-berseem mixture was highest in fibre content, and this was followed by the crops of oats pure, berseem pure, oat+senji and senji pure. The differences in crude fibre in oat-berseem mixture, oats pure and berseem pure were statistically non-significant.

9. The practice of growing legume and non-legume in association invariably resulted in higher production of N-F. E. Pure oats ranked next in this respect which was closely followed by berseem pure. The poorest performance was that of senji. As regards per cent content of N-F. E. no difference was noted amongst berseem, oat-berseem, oat-senji and oat forages in the first year; while senji grown alone analysed significantly lower N-F. E. content than other crops. In the second year oats contained the highest N-F. E. followed by oat-senji, oat-berseem and berseem, while senji was the poorest in this as well.

10. Senji and berseem grown pure were more succulent than oats and its mixtures.

11. The per cent contents of crude protein crude fat and mineral matter of oat-berseem mixture were better at almost all the stages than that of the mixture made out of the two components grown separately, while the proportion of crude fibre and N-F. E. was reduced in former case. The variations in case of oat-senji were not well marked.

12. The productions of starch equivalent, crude protein, crude fat, mineral matter and N-F.E. on equal area basis i.e. the yields of one hectare mixed sown plot compared with that of the combined yields of the two components grown separately each in half a hectare plot, were appreciably higher in case of the former than that of the latter.

13. Nitrogen and available phosphorus contents of the soil were much improved where legumes were grown either alone or in association with oats, while total phosphorus content was least in the soil where senji was grown and it was highest in the plots of oats.

14. Combined application of nitrogen and phosphate (44·8 kg. each) proved superior to its separate applications and control with respect to growth, survival and the productions of forage, starch equivalent, crude protein, crude fat, mineral matter and nitrogen-free extract.

15. With the application of nitrogen alone or in combination with phosphate the nutritive ratio was significantly narrowed down and the percentages of crude protein, crude fat; mineral matter, crude fibre and moisture were generally increased, while the proportion of N-F.E. was reduced appreciably.

16. Nitrogen and available phosphorus contents of the soil were improved with the application of nitrogen plus phosphate. Total phosphorus content in the soil was highest in the plots treated with phosphate alone.

17. The improvement in the forage yield of berseem or oat-berseem was excessively large in the succeeding years.

18. The efficiency of nitrogen plus phosphate remained high from the very beginning and it further improved appreciably in the following years.

19. Oat-berseem mixture responded most to the application of nitrogen plus phosphate (44·8 kg. each) with respect to the production per hectare of green and dry matter and that of starch equivalent, crude, protein, mineral matter and nitrogen-free extract; while crude fat production per hectare was maximum with oats treated with nitrogen plus phosphate.

20. Oat-berseem mixture fertilized with nitrogen plus phosphate (44·8 kg. each) proved to be the most remunerative treatment.

CONCLUSION

From the results summarised above the following main conclusions may be drawn:—

1. The quantity and quality of oat-berseem forage are improved when sown mixed. The inclusion of legume in the forage mixture also improves the soil fertility.

2. Growing of oat-berseen with the application of nitrogen plus phosphate each at the rate of 44·8 kg. per hectare is most remunerative. With this manurial practice both the yield and quality of the forage are much improved.

On the basis of yield and quality of forage, economics and soil building results, the practice of growing oat-berseem mixture with nitrogen and phosphate each at the rate of 44·8 kg./ha. may be recommended to the cultivators of Agra region.

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Author is highly grateful to Dr. R.R. Singh, Professor and Head of Agronomy Department, R.B.S. College, Bichpuri, Agra for his valuable guidance.

REFERENCES

1. Banerji, J. 1951. Proceedings of the sixth inter ational grassland Congress. p. 513.
2. I.C.A.R. 1961. Hand book of Agriculture. Indian Council of Agricultural Research, New Delhi. p. 260–297.
3. Semple, A. T. 1952. Improving world's grasslands. An F. A. O. study.

TYPING AND SEROLOGICAL STUDIES OF FOOT-AND-MOUTH DISEASE VIRUS[1]

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The main aim of carrying out this investigation was to assess the value of certain serological methods for typing of Foot-and-Mouth disease virus. Studies were primarily conducted on complement fixation and gel diffusion tests.

Sixty-eight samples received from eleven different outbreaks suspected to be of Foot-and-Mouth disease were tested by complement fixation test with original material. Twenty-five per cent samples could be typed by complement fixation test conducted on original material. Three field samples, negative for Foot-and-Mouth disease virus by complement fixation test, were once passaged in suckling mice and then could be successfully typed by complement fixation test.

Forty serum samples collected from animals recovered from Foot-and-Mouth disease were tested by complement fixation test to detect their antibody content. Thirty-two serum samples from 8 calves recovered from Foot-and-Mouth disease were collected at 7th, 14th, 21st and 28th days of the appearance of lesions and tested for presence of complement fixing and precipitating antibodies. Complement fixing antibodies were detectable in serum samples collected after seven days of the appearance of the lesions. Highest serum titres were seen after two weeks of the appearance of lesions. Complement fixing antibodies in lowtitres were detectable in serum samples collected after 28 days of the appearance of lesions. Serum samples from the recovered calves which were collected at 60th day after the appearance of the clinical symptoms gave negative complement fixation test. Precipitating antibodies from the recovered calves were detectable by gel diffusion test from 7th to 28th day after the appearance of the lesions.

Antigenic studies were carried out by gel diffusion technique using O.A.C. and Asia 1 strains of Foot-and-Mouth disease virus and their corresponding antisera. Two lines were obtained with homotypic antigen and immune serum. The gel diffusion test was found to be type specific as no cross precipitation was observed between heterotypic antigen and immune serum.

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[1] An abstract of the thesis submitted to the Agra University in partial fulfilment of the requirements for the award of M. V. Sc. degree in Bacteriology (1956).

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Antigenic relationship between O and A types of Foot-and-Mouth disease virus was also studied by gel diffusion test. It was concluded that larger components of O and A types have no antigenic similarity with each other. On the other hand the smaller components have a complex antigenic structure. At least one antigen of the smaller component of O is in common with smaller components of A, the other antigen in each is different.

Buffalo embryo kidney cell culture was processed and continuous monolayer cell sheet was obtained within seven days of the initial culture. Both the fibroblasts and epithelial cells were present in the monolayers of cell culture. Primarily, guinea pig adapted type O Foot-and-Mouth disease virus, was inoculated into cell culture. Cytopathic effects of the virus on cells were seen. The cytopathic changes were characterised by destruction of cells, swollen appearance of the cells, condensation of nucleus and vacuolation of cell cytoplasm.

STUDIES ON PHAGE TYPING OF *ESCHERICHIA COLI* STRAINS FROM DOMESTIC ANIMALS AND POULTRY*

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The present studies were undertaken with a view to divide *Escherichia coli* strains of avian, ovine and porcine origin into different phage-types as very little work has been done in this direction.

In all 151 strains of *E. coli* were isolated from 634 animals. These isolations were made by direct plating of the materials on the MacConkey's bile-salt neutral-red lactose-agar (MLA) medium, which were confirmed to be *E. coli* by their IMViC (indole, methyl red, Voges Proskauer and citrate utilization) pattern, by fermentation reactions in lactose, glucose, inositol, adonitol and mannitol and other biochemical tests. Organisms which were Gram negative (—), generally motile; nitrate reduction positive (+), indole +, methyl red (MR) +, Voges Proskauer (VP) —, citrate utilization—, H_2S—, urea hydrolysis—; fermented promptly sugars lactose, glucose and mannitol with the production of acid and gas (AG) and which did not ferment sugar inositol or adonitol, were taken to be *E. coli*. Certain non-motile, weakly H_2S + and anaerogenic strains of *E. coli* were also encountered. Atypically mucoid and biochemically dissimilar strains were of interest. Out of 151 *E. coli* strains 78 were from 417 birds with various pathological conditions, 12 from 26 lambs with diarrhoea and 61 from 191 pigs.

Smith and Crabb's method (1956) was employed with slight modifications for the isolation of bacteriophages against *E. coli*. Nine bacteriophages were isolated from faecal matter and sewage water by adapting such a technique.

In all phage typing of 120 *E. coli* strains of avian, ovine and porcine origin was done with 19 phages (including ten Dr. S. S. Kasatiya and Dr. C M. Singh's phages). Of the 74 *E. coli* strains from poultry 65 were typable and were divided into 34 phage-types. The nine *E. coli* strains from scouring lambs were divided into six phage-types and out of 37 *E. coli* strains from pigs 33 were divided into 17 phage-types. Rest of the strains were untypable with the phages used in the present studies. It was interesting to note that chicks were found to acquire *E. coli* infection not from intestine but from some other source. The phage-typing results were also correlated with serological typing. Many serotypes were traced to have a common source of origin while others belonged to diversified sources. Phage-typing results indicated that the scouring piglets did not acquire pathogenic *E. coli* from either the normal sows or neighbouring normal piglets, but from some extraneous source, which might be the feed supplement or the feeding manger. It has also been indicated that phage-types may be different from place to place.

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Pathogenic *E. coli* strains isolated from poultry possessed 'O' antigen 1, 8 and 78. Few strains were untypable. All these *E. coli* types of avian origin were recorded for the first time in India.

The necessity of carrying out further research work on serological as well as phage-typing of *E. coli* strains from various sources particularly from clinical conditions is stressed to elucidate their epidemiological importance in India.

SEROLOGICAL STUDIES ON DIFFERENT TYPE STRAINS OF *LISTERIA MONOCYTOGENES**

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Recent literature on the host range, pathogenicity, biochemical reactions, antigenic structure and serotyping of *Listeria Monocytogenes* has been reviewed in detail.

As is well-known, it was obserbed that the biochemical reactions alone were inadequate to make out differences among the *Listeria* strains.

Study on colonial morphology of a rough strain of *Listeria* revealed that the smooth forms could be obtained from apparently rough forms after 3 successive passages of the latter in 10-day old embryonating hen eggs. However, it could not be vouchsafed whether it was a 'true' reversion or only an 'apparent' one.

Out of eleven type strains studied, only one strain, [illegible], la, possessed the property of causing haemolysis of blood cells of sheep, goat, horse, mule, bull, rabbit, guinea-pig and fowl.

The possibility of presence of an oxygen-stable, heat-labile and formalin-sensitive factor, closely linked to the surface of the haemolytic strain of *Listeria* (la), has been brought to light. This factor appeared to be antigenic. Study of flagellar antigens by different tests showed that type 2 and type 1 strains of *Listeria* can be distinguished from strains of type 3 and 4 on the basis of cross agglutination reaction with type antisera. It was further suggested that differentiation between strains, having flagellar factors AB and ABC was possible, when these strains were cross reacted with la and lb antiserum. Results of indirect bacterial haemagglutination test showed that heating of broth culture of *Listeria* for 3 minutes at 93°C solubilised erythrocyte-sensitizing antigens, which seem to be commonly shared by all strains of Listeria.

Study of heat stable antigens among different strains of Listeria and 2 strains of *Staphylococcus* and one strain of *C. ovis*, by agglutination test, disclosed that coagulase-negative strain of *Staphylococcus* shared II, III, V, and IX heat stable 'O' factors in common with strains of *Listeria.* Coagulase-positive strain of *Staphylococcus* and *C. ovis* did not show any cross-agglutination reaction with antiserum prepared against five strains of *Listeria.*

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Indirect bacterial haemagglutination test, however, could show cross reaction between *Listeria*, 2 strains of *Staphylococcus* and one strain of *C. ovis*.

Interface (ring) precipitation test has indicated that acid extract prepared from different strains of *Listeria* can give type specific reaction with homologous serum.

Indications have been obtained from study of heat labile antigens that heat labile somatic factors can show cross reaction for unrelated heat stable factors, e.g., 3b unheated formalised cell has shown cross reaction with factor serum IX which is not present in 3b after heat treatment, Similarly, 4d unheated formalised antigen has cross-reacted with factor sera II, which is not present in 4d after heat treatment. The occurrencc of a heat labile new factor 'L' common to 3b and 4a types has been suggested probably for the first time.

AFFECTIONS OF LOWER ALIMENTARY TRACT (ALAT) OF DOMESTIC FOWL—A MORPHOLOGIC STUDY*

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The studies on the affection of lower alimentary tract was undertaken to elucidate the morphology, pattern and distribution of lesions in various diseases. The material included in this study was obtained from the autopsies 5573 birds during April, 1966 to March, 1967 in the Department of Pathology at U.P. College of Veterinary Science and Animal Husbandry, Mathura. Out of 1279 birds showing gross lesions in the lower alimentary tract the histopathology was conducted on 340 selected cases. The history alongwith gross lesions observed were mapped out on a diagram and the places of collection of the tissues were also marked.

The aggregate mortality rate at this farm was directly proportional to the affections of lower alimentary tract. The highest mortality rate was observed due to Salmonella in 2-25 days old chicks and the deaths due to ALAT were next important condition. The affections of this system appeared to persist on college Poultry Farm throughout the year and peak of mortality was in the month of April and December.

Amongst the different types of ALAT the coccidial enteritis was commonest in chickens of 8-16 weeks of age. The possibilities of predisposition of age factor supplemented by the effect of season were also indicative. In the younger age groups of chicks (1-5 week of age) the other conditions were mycotic ingluvitis and vent gleet. In adult birds of 16 weeks and above the helminthic enteritis, neoplastic condition, ulcerative enteritis, proventriculitis and ventriculitis were in order of frequency. The intestinal helminthiasis has heen considered to produce more severe effects in chicks than adult birds.

The relationship of ALAT to different sex and breed indicated the lesions of ingluvitis and ventriculitis in males and that of preventriculitis and ulcerative enteritis in females. An increased susceptibility to lighter breeds like white Leghorn to intestinal helminthiasis was an interesting finding.

The lesions of ingluvitis in younger chicks were of mycotic origin while in adults the etiology of ingluvitis could not be ascertained. The necrotic proventriculitis (6 cases) and ventriculitis (4 cases) with mucosal ulcers and fibrinous deposits has been described and the necessity for finding out the etiology has been suggested. A case of traumatic ventriculitis along with fibrinous peritonitis has been reported.

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The morphology of lesions in ulcerative enteritis observed in 15 cases has been suggested to be similar to "Quail diseases" though the presence of coccidial infection in some of these cases was also noticed. The complication of the intestinal coccidiosis in poultry has been stressed with regard to the difficulties in the treatment.

Lesions of coligranuloma like Hjarre's disease have been reported along with the concomittent mycotic infection in few cases. The possible relationship of coligranuloma lesions in digestive tract of female birds to salpingioperitonitis has been pointed out.

Besides the gross and histopathology of lesions in coccidiosis the disruption and degeneration of lamina muscularis alongwith retrogressive changes of Auerbach's plexus were the important features of the disease. The extension of infection through lymphatics resulting in the over distension of the lymphatic plexus passing through the muscular coat has been postulated as the cause of damage to the muscular coat. Banana shaped structures resembling merozoits in the sinusoids of liver suggested an ectopic dissemination of coccidial infection through hematogenous route. Microscopically the lesions of coccidiosis ranged from acute haemorrhagic reaction with necrosis and ulceration to subacute and chronic type of inflammation. The phagocytosis of merozoits by macrophages was seen after employing PAS method of staining. The correlation between the clinical manifestation and development of lesions was also inferred.

In helminthic enteritis the histopathologic changes featured in general, the prominently enlarged caecal tonsils and lymphoid hyperplasia.

The findings of lymphomatosis lesions in the cloaca-oesophageal end of proventriculus and gizzard were significant contribution towards the estimate of distribution in involvement of organs in visceral lymphomatosis. The observation of an adenoma of ileum in a pullet has been described.

The association of coccidiosis in the development of intussusception has been discussed as a possible factor in the etiology of this ailment. The cause of strangulation in a 17 days old cockrel has been attributed to the stalk of the yolk sac which encircled the loop of the intestine during its regression phase.

The cases of vent gleet were mostly in chicks aged 1-15 days except in a pullet which was 7 week old. The histopathology of lesions in all these cases has been described and further studies to understand the nature of this affection was indicated.

The location and distribution of pathologic changes in different parts of the lower alimentary tract offered a pattern though without much precision of uniformity in different forms of ALAT.

The ulcerative enteritis in adult chickens was more or less confined to jejunum, ileum, caeca colon and rectum.

In salmonellosis amongst 2-25 days old chicks whole of the intestinal tract was involved featuring with petechial haemorrhages in duodenum, jejunum and terminal part of ileum. In addition the mottling of the liver and distension of gall bladder were the most constant lesions of the disease.

The pathologic alterations in coligranuloma simulating Hjarre's disease appeared to exhibit specific configuration characterising the distribution of nodular lesions on the serosa and outer coat of proventriculus, gizzard, tips of caeca and colon.

The chicks aged 1-4 weeks (Group I) had the lesions associated with schizonts and gametocytic stages of coccidia in the form of petechial haemorrhages and congestion. These were either confined to the duodenum along with occasional extension to jejunum or only in ileum. The caeca and colon were, however, entirely spared. In 4-8 weeks old chicks some cases had the location of lesions in ileum alone featuring distension and severe haemorrhages. No marked variation in the pattern of distribution of lesions could be established in older age group of chickens ranging from 8·16 weeks and above.

The determination of the morphologic pattern of lesions has been considered an essential tool in formulating tentative diagnosis of poultry diseases during autopsy specially in case where intestinal tract was involved. At the same time, the necessities for further investigations in determining the species infection of coccidiosis in relation to the pattern of lesions are emphasised.

STUDIES ON THE METABOLIC ACTIVITIES AND PATHOGENICITY OF STAPHYLOCOCCUS AUREUS OF BOVINE UDDER ORIGIN[*]

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In the present investigation qualitative and quantitative studies on certain metabolic activities of *Staphylococcus aureus* of bovine udder origin were undertaken with a view to find out, if there exists any possible correlation between the metabolic activities and pathogenicity. A review of the available literature on the subject has been presented.

As an adjunct to this study, a limited survey of the staphylococcal flora of apparently healthy bovine udders was conducted. One hundred and four isolates of staphylococci were obtained from bacteriological examination of 236 milk samples. Among the isolates there was preponderance of *Staphylococcus aureus* (55 per cent).

The results of qualitative studies on one hundred and twenty-two strains of *Staphylococcus aureus* for their biological characters such as, coagulase, fibrinogen and lipase production, haemolysis, reaction in litmus milk, reduction of nitrates and methylene blue, liquefaction of gelatin, pigmentation, fermentation of mannitol and lactose and production of opacity in egg-yolk medium indicated that there was no recognizable pattern of distribution of these properties among the pathogenic and non-pathogenic strains. Coagulase production and haemolytic activity were closely related to pathogenicity in a significantly higher percentage of cases, though a smaller proportion of non-pathogenic strains also exhibited these two properties.

There was a close parallelism between the fermentation of mannitol and the ability to produce golden pigment among the pathogenic and non-pathogenic strains of *Staphylococcus aureus*. The correlation of these two properties with pathogenicity was not conclusive.

'Egg-yolk factor' negativity in majority of strains appeared to have an inverse correlation with coagulase production. Lipolytic activity did not show any appreciable correlation with the other activities.

Quantitative estimations of coagulase production, arginine break down and urease and catalase activities in respect of seventy-two strains of *Staphylococcus aureus* yielded much useful information regarding their internal relationship between these properties on one hand and the correlation of these activities with pathogenicity on the other.

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There was a suggestive inverse correlation between urease activity and coagulase production. The fact that non-pathogenic strains were more ureolytic gives an added significance and indirect evidence to this observation. A close parallelism was noticed between urease and catalase activities of the strains. Similarly direct but a faint relationship was noted between the production of coagulase and arginine break down. Other activities were apparently unrelated to coagulase production. Quantitative studies made with a limited number of strains for the *alpha* toxigenicity and coagulase production brought to light a direct relationship between these two properties.

Observations with eleven strains of *Staphylococcus aureus* which were both *alpha* toxigenic and coagulase positive, revealed that ten of them were pathogenic to mice while the remaining one which was recovered from an apparently healthy bovine udder was non-pathogenic.

It was also observed that a few of the strains of *Staphylococcus aureu* of bovine mastitis origin did not prove pathogenic to mice—a finding which suggests that biological test in mice is not absolutely perfect in the detection of potentially pathogenic strains from animal sources.

From the findings in respect of pathogenicity it could be concluded that the pathogenic behaviour of staphylococci is determined by a multiplicity of factors and that there is no single criterion on which complete reliance could be placed upon. It is also shown by the results presented here that *alpha* toxigenic and coagulase activities when taken together prove to be a better indication of pathogenicity than either of these properties 'per se'.

STUDIES ON PULMONARY TISSUE REACTION BY INTRATRACHEAL INOCULATION OF PASTEURELLA MULTOCIDA AND CORYNEBACTERIUM PYOGENES IN GOATS

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Experimental production of pneumonia by Pasteurella multocida and Corynebacterium pyogenes has been achieved by several workers[1-9] but very little is known regarding histogenesis of this condition. In the present investigation an attempt was made to study the changes in pulmonary tissue, in early as well as late stages of infection, to determine the nature and pattern of tissue reaction.

The lesions of pneumonia were produced in the lungs of 77 kids* by the intratracheal inoculation of 24 hour old pure culture of Pasteurella multocida and 48 hour old culture of Corynebacterium pyogenes, grown on serum broth. The kids were treated with sulphamezathine and phenothiazine for any intestinal helminthic and protozoan infection before inoculation of the above cultures. The primary lesions appeared as small foci in the right apical and cardiac lobes. The size of the lesions was smaller in the beginning which later formed into bigger areas by coalescence of the smaller ones. The lesions spread quite rapidly, with multiplication of the micro-organisms in the parenchyma, in all directions and continued to spread until arrested by the pleural membranes or inter-lobular septa. The most important mode of spread of the microorganisms from infected to the normal parenchyma was by the outflow of the oedematous fluid through smaller air passages. Aided by the respiratory process, the organisms, propagating in this fluid devoid of leucocytes at the initial stage, passed through the pores of Cohn. Another probable way of spread of infection appeared to be the active migration of leucocytes and macrophages from an infected zone to normal tissue after phagocytosis of the micro-organisms.

There were gradual and progressive changes in the character of the exudate and the nature of the infiltrating cells as the disease progressed. The microscopic finding could be more closely correlated with the age of the lesions rather than with their gross appearance or with the clinical condition of the animal at the time of death or destruction.

The earliest cellular response is the swelling of alveolar endothelial cells, followed closely by their degeneration and infiltration of the alveoli by the polymorphs and mononuclear cells which soon dominated the alveolar exudate.

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The inflammatory cells in the exudate came principally from the blood and partly from the injured tissue. Erythrocytes and fibrin regularly constituted a part of the alveolar exudate but varied considerably in their relative concentration, depending upon the intensity of irritation. The thickening of the inter-alveolar septa and peribronchial hyperplasia of lymphoid tissue as well as connective tissue were also some salient features.

In both types of infection, the polymorphonuclear leucocytes were the first to invade the irritant but, after an interval of 3 hours in the case of Pasteurella infection, there was disappearance of polymorphs and preponderence of mononuclear cells lasting upto 12 hours of infection. This indicated the influence of some negative chemotactic agent. Thereafter when necrosis supervened polymorphs again invaded the tissue in increasing number. On the other hand, in case of Corynebacterium infection, no such picture is revealed. The polymorphonuclear leucocytes seen in the early stages of pneumonia, were gradually replaced by larger phagocytic mononuclear cells, in many cases, which appeared to have resulted from transformation of monocytes into larger phagocytic cells. The local septal cells also contributed, to some extent, to the origin of the macrophages but it was very difficult to make any distinction between them and those of haematogenous origin.

All the stages of pneumonia, namely congestion, red hepatization, grey hepatization and resolution were observed in the lungs. Besides, the kids inoculated with *P. multocida* showed gross distention of the interlobular septa, while those inoculated with *C. pyogenes* had developed small suppurative foci. The necrosis of the parenchyma was an essential feature in case of lesions caused by *C. pyogenes*, but less so with the *P. multocida*. The suppurative foci did not reveal fibrous capsule around them to limit their spread, but they coalesced to form bigger suppurative areas.

The exudate, in the case of *C. Pyogenes* inoculated kids, was purulent in nature, while in pasteurella infection it was serofibrinous. Fibrous pleuritis was a marked feature of the chronic cases due to *C. pyogenes* infection but this was not the characteristic of pasteurella infection.

The first evidence of resolution appeared as early as 48 hours after inoculation, but 7 days or more were required for complete resolution of infection with pasteurella, while corynebacterium produced chronic changes rather than recovery. The stage of resolution was characterised by presence of large number of macrophages which were chiefly responsible for the liquefaction of the fibrinous exudate. The resultant thickening of the alveolar walls after the resolution had occured was in large part due to increase in the number of the swollen septal cells.

A comprehensive account of the above findings will be published later else where.

REFERENCES

1. Borgman, R. F. & Wilson, C. E. 1955. *J. Amer. Vet. Med. Ass.*, **126** : 198.
2. Cornell, R. L. 1938. *Vet. Rec.*, **50** : 1953.
3. Carter, G. R. & Rowsell, H. C. 1958. *J. Amer. Vet. Med. Ass.*, **132** : 187.
4. Jowett, W. 1930. *J. Comp. Path.*, **43** : 109.
5. Lebedev, M. A. 1937. Trud. vsezoyuz. sksp. Inst. Vet. **14** : 144.
6. Lovell, R. 1945. Vet. Rec., **57** : 683.
7. McGowan, B., Moulton, J. E. & Shultz, G. 1957. *J. Amer. Vet. Med. Ass.* **131** : 318.
8. Pande, P. G. 1943. *Indian J. Vet. Sc.*, **13** : 44.
9. Pierre R. 1951. Role pathogene de *Corynebacterium pyogenes* dans l' espece bovine, Thesis, Alfort, pp. 74.

SEROLOGICAL STUDIES IN JOHNE'S DISEASE*

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The main object of the present study was to analyse the antibody response against *Mycobacterium paratuberculosis* in vaccinated as well as naturally and artificially infected animals. For this purpose various groups of animals were vaccinated with different vaccines and their allergic and antibody response was analysed with the help of allergic and indirect bacterial hamagglutination tests. The double intradermal test using johnin (HCSM) was employed to study the allergic response in vaccinated animals at various intervals. It was interesting to note that with intradermal vaccine, the allergy developed earlier in goats than in sheep, disappearing completely after 2 months. In animals vaccinated subcutaneously, allergy, developed earlier than intradermally vaccinated animals and persisted for longer period of time.

5 sheep and 5 goats were artificially infected by inoculating intravenously 80 mgm. of *Mycobacterium paratuberculosis.* But all the goats died due to adverse climatic conditions. Out of 5 sheep, only one animal developed allergy after 4 months and acid-fast bacilli were found in smears of intestine of two animals, one of which was positive and the other negative to allergic test.

The vaccinated animals were also tested intravenously with johnin (HCSM), johnin P. P. D. and avian P. P. D. 7 goats and 9 sheep vaccinated subcutaneously with adjuvant vaccines were tested with 2 ml. of johnin (HCSM) intravenously, keeping 3 sheep and 3 goats as control. Significant rise in temperature (3·0-4·8°F) was observed, the maximum being at 7½ hours. 5 sheep and 4 goats were tested with 4 mgm. of johnin P. P. D. dissolved in 2·5 ml. of Eagle's Salime, keeping 2 sheep and 2 goats as controls. After 4½ hours significant rise in temperature ranging between 4·5-5·2°F in sheep and 3·6-5·6°F in goats was observed. Similarly, 6 sheep and 4 goats were tested with avian P. P. D., keeping 2 sheep and 2 goats as controls. Significant rise in temperature ranging between 2·8-4·6°F in sheep and 3·2-5·4°F in goats was observed after 4½ hours. This indicated that johnin P. P. D. and avian P. P. D. gave better thermal response than johnin (HCSM). The duration of thermal response lasted for 4½ hours with either of the P. P. D. but it was less with johnin (HCSM). Since it would not have been possible to get a large number of natural reactors at a time, the test was done on vaccinated animals. This test is although time consuming and cumbersome but very useful in detection of individual cases of Johne's Disease in an infected herd.

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Serum samples were collected from 96 animals vaccinated with different vaccines and put to indirect bacterial hamagglutination test which gave significant titre. It was interesting to note that sheep erythrocytes gave non-specific reactions with large number of healthy sheep and goat sera. This necessitated the selection of erythrocytes from some other species of animal which may not give non-specific reactions. In intradermally vaccinated animals the response of H. A. antibodies was comparatively less than that of subcutaneously vaccinated ones. With live and killed adjuvant vaccines, the response was more or less of similar pattern. It is worth while mentioning here that after 10 weeks of vaccination, the H. A. titre considerably went down in all groups of vaccinated animals and thereafter gradual rise in titre was noticed. Some of the animals vaccinated intradermally which did not indicate any allergic response nor developed nodule showed high titre of H. A. antibodies.

In artificially infected animals the response in H. A. titre was comparatively poor, the titre ranging between 1 : 40 to 1 : 640. On post-mortem examination, 2 animals revealed the presence of acid-fast organisms. There was no rise in H. A. titre in the animals which were tested with johnin by intravenous route.

Serum samples from 95 animals which were positive on double intradermal test gave significant H. A. titre ranging between 1 : 40 to 1 : 1280. It was most interesting to note that some of the animals which gave doubtful reaction with johnin test in early as well as advance stages of infection gave significant high titre with H. A. test. It was concluded that titre of 1 :40 and above with goat erythrocytes was of diagnostic value and had advantage over allergic test in detecting latent cases as well as advance cases where latter test was unsatisfactory. The hamagglutinating antibodies developed earlier than delayed hypersensitivity in the artificially vaccinated animals.

The dilution of antigen ranging from 0·5 mgm. to 2·0 mgm. per 0·6 ml. of Eagle's Saline had no effect on H. A. titre. In order to study the Cross reactivity of johnin P. P. D. with that of tuberculous avian and mammalian P. P. D., haemagglutination test was employed on 6 positive serum samples and it was observed that H. A. titre with all the P. P. D. was more or less the same. This clearly indicated that these P. P. Ds were antigenically related to one another. This test cannot be useful where there is mixed infection of Tuberculosis and Johne's Disease in a herd.

Complement-fixation test was conducted on 8 serum samples from the animals which were found to be reactor to the double intradermal test with johnin, using culture filtrate as antigen. Only 2 sera gave titre of 1 : 40 while others gave only upto 1 : 10. Nothing could be definitely concluded because it required further work.

Gel-diffusion test was carried out both by double-diffusion technique and with the help of micro-immunoelectrophoresis. For this purpose various antigens namely unsteamed and steamed culture filtrate, freezing and thawing antigen from bacilli, autoclaved extract of bacilli, johnin P. P. D., tuberculous avian and mammalian P. P. D. were used. Hyperimmune sera were mainly prepared in sheep and rabbit and were employed in this test. Besides antisera from goat as well as from naturally infected and vaccinated animals were also used in order to analyse various precipitinogenic antibodies present therein.

Hyperimmune serum prepared in rabbit gave a maximum of 2 lines both in double-diffusion as well as in electrophoresis and only one line against johnin P.P.D. No line could be obtained with other antigens. With hyperimmune sheep serum a maximum of 5 lines could be detected with unsteamed culture filtrate. It was also observed that many bands had common antigenic components in different preparations. Antigen prepared by freezing and thawing had 3 common bands with unsteamed culture filtrate and one common band with steamed culture filtrate. No specific line could be detected with avian and mammalian P. P. D. but two lines were observed with steamed avian filtrate which were indentical with that of unsteamed culture filtrate of *Mycobacterium paratuberculosis*. This clearly revealed the closer antigenic relationship in precipitinogens of *Mycobacterium avium* and *Mycobacterium paratuberculosis* but not with *Mycobacterium hominis.*

Micro-immunoelectrophoretic studies had more or less similar results except with johnin P.P.D. 3 lines developed as against 2 in double-diffusion. The serum samples from vaccinated as well as naturally infected animals produced only one line in micro-immunoelectrophoresis with steamed and unsteamed culture filtrates but failed to produce any line in double-diffusion technique. Contrary to this, freezing and thawing antigen from bacilli gave three bands in double-diffusion but no band in micro-immunoelectrophoresis. Migration of antigens to either of the poles was not marked.

Small nodules varying in size from 6·5 mm. to 8·5 mm. appeared in intradermally vaccinated animals 10 days after vaccination of Johnes bacilli in N. S. S Some of the animals did not develop nodule. The nodules disappeared 2 months after first vaccination but reappeared 10 days after second vaccination. In subcutaneously vaccinated animals a well developed nodule ranging in size from 15 to 20 mm. in diameter developed after 2 weeks of vaccination, the vaccine used had 3% of lanoline. Contrary to this 7% of lanoline incorporated with the vaccine produced closed abscess at the site after 1 month of vaccination extending upto hock joint. Later on the abscess became opened. The pus from the abcess was found to be sterile. Some of the animals which were challenged with heavy doses of living organisms (900 mgm. of *Mycobacterium paratuberculosis*) after 1 to 2 years of vaccination did not pick up infection after 4 months of challenge. This indicated that the vaccine had protective value under field condition as well as under artificial stress.

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ON THE MORPHOLOGY AND BIONOMICS OF *TINGIS BUDDLEIAE* DRAKE (HETEROPTERA : TINGIDAE)*

PART I—BIONOMICS

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INTRODUCTION

Bionomical studies made by the author on Tingidae have proved that this small group of insects, if neglected, can create major problems for the economic entomologist, with regard to their control. Biological control measures can be easily applied against these bugs with success, as their spreading capacity appears to be poor. This is the sixth paper "On the studies of the population and bionomics of Tingidae", published by the author. The behaviour of these insects was mostly studied in the field while the incubation and stadial durations were studied under laboratory conditions.

I am deeply grateful to my Professor Dr. T. Singh, School of Entomology, St. John's College, Agra for his encouragements and guidance, to Rev. P. T. Chandi, The Principal, St. John's College, Agra, for permission to work in the School of Entomology and encouragements, and to Dr. Santokh Singh and Dr. Ipe M. Ipe for help in various ways. I am also grateful to the Ministry of Education, Govt. of India, for financial assistance during the tenure of the work and Dr. C. J. Drake of Smithsonian Institution, for confirming my identification of the species.

DESCRIPTION OF THE INSECT

The original description of this species by Drake (1930) is inadequate and hence it is being redescribed here.

Tingis buddleiae, (Figs. 1 and 2) is 3·2 mm. long 1·4 mm. broad, elongate ovate, light brownish testaceous with dark patches at the sub-apical margins of the sutural area and the middle of the sub-costal area; pigmentation is much deep on these areas, on the tarsi and on the terminal antennal segments in the winter forms.

Head, declivent, bearing five prominent, rather sharp, porrect scoli, telescoped into the prothoracic anterior extension up to the level of the dark brown, sub-spherical compound eyes. The exposed dorsal area of the head, the pronotum, the sternites of the thorax and the abdomen clothed with white, fine, wavy setae. First two antennal segments slightly swollen and almost equal in length; third segment setaceous, slender and longest; fourth segment clavate, dark brown and much setaceous. Bucculae enclose the basi-rostral

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segment and closely approximate on either side of the labrum. Four segmented rostrum reaches the metasternum; third and the fourth rostral segments pigmented, the former with an intra-segmental transparent membrane. Four serially areolated paranotal expansions extending upto the eyes; the notal expansions as well as the outer margins of the corium spinous; proscutum tricarinate, each carina unserially areolated; median carina extending from the anterior to the posterior end while the lateral ones originate anteriorly on dark depressions and posteriorly terminate sub-apically; the posterior and anterior extensions as well as the paranotal expansions broadly areolated while the middle convex region of the scutum finely reticulate. The clavus, hidden by pronotal posterior extension; the corium with four distinct areas:—triserially areolated subcostal area, biserially areolated radial area, five serially areolated discoidal area and multiserially areolated sutural area; the corium, extending about 0·6 mm. beyond the body, entirely covering the hind wing. The metathoracic legs slightly more elongated than the first two pairs of legs; the procoxae closely approximate each other while the meso- and meta-coxae rather widely separated; carinations bordering the sternal furrow uniserially areolated.

In the original description, Drake (1930) seems to have observed whitish exudations on the head, pronotum and on reticulations. Such exudations have not been observed on specimens collected here in Agra. The genital segments of males are slightly narrower than those of the females.

HOST PLANTS AND NATURE OF DEMAGE

The species *Tingis buddleiae* is a phytosuccivorous bug on *Buddleia asiatica* and *Buddleia madagascarensis* of the family Loghaniaceae. The damage caused by these bugs to the shrub during the peak population is severe, resulting in crinkling, drying and ultimate withering of both leaves and buds. These plants bear white inflorescence having sweet fragrance and grow well to form hedges in gardens.

INCIDENCE AND REARING

T. buddleiae was first described from Phillipines by Drake (1930) and was recorded in the Orient for the first time in 1958-59 on *Buddleia madagascarensis* and *B. asiatica* in Agra, U.P. by the author (Livingstone, 1961). Since then, the population fluctuations and incidence of these bugs have been closely studied, selecting only a particular plot of *B. asiatica*. Fortnightly random collection of infested leaves was made, the number of individuals on each leaf recorded and the average was taken for ten leaves. The results, thus obtained during the years 1959 to 1962, are tabulated in table 1. The study reveals a very interesting population pattern. The peak population is reached during the winter months of November to March, when the maximum average temperature ranges between 65° to 80° F. It is significant to note that the maximum density of the population was recorded during the year 1960-61, when the maximum average temperature showed the lowest value during the whole period of the study. During the year 1961-62 the Tingis population in the same area was the lowest. A comparative study of the three years observations suggests a possible cyclic periodicity in the Tingid population. It is worth while to record here that a study of the different plots in the same locality showed, that, when there was a fall in the population in one plot or even on one bush of the same plot, there was a rise in the population in another plot or another bush of the same plot in the following year. When the bugs were entirely missing in one locality they were found heavily infesting the bushes of another locality. The population during the winter months consisted mainly of females but the sex ratio beams equal when the population was high during other seasons, as reported by Dickerson and Weiss (1917) in *Stephan'tis pyrioides.*

The twigs bearing the insects were carefully cut and immediately dipped into tubes containing water and their leaves were examined for eggs. The leaves bearing eggs were isolated, kept in separate tubes covered with gauze and examined periodically. Immediately after the emergence, the immature stages were transferred to fresh leaves to study the nymphal periods, Table 3. During the months of March and April, leaves could be preserved in this way for more than fifteen days.

COPULATION

The bugs begin to copulate three to five days after the last moult. The male, after fluttering its wings beside the female, climbs on the back of the latter which continues feeding. While the female moves about carrying the male on its back, the latter extends its genitalia posterio-laterally, manoeuvering the female's genital opening. After repeated attempts, the male succeeds in inserting the intromittent organ right into the genital chamber of the female and then takes its position on one side of the female at an angle of about 60°. Both the partners remain in this position for about 15-30 minutes, with their heads drooping and antennae raised. When the whole process is over both the partners move to different spots to feed. A similar behaviour has been observed in *Rhinocoris* by Odhiambo (1959).

OVIPOSITION

Each female lays 12 to 50 eggs (Table 2) generally on the lower surface of the leaf, near the side veins and leaf tips in preference to midrib. The eggs are laid scattered unlike other Tingidae e.g., *Stephanitis* and *Monanthia,* as observed by the author. It is easy to detect the presence of the eggs in the leaf by looking at its smooth upper surface, as at these places the epidermis bulges out and becomes transparent. The lower epidermis is velvety and thus camouflages the operculum of the eggs.

The deposition of the egg takes about five to eight minutes. At first the second gonapophyses puncture the leaf tissue and then the first gonapophyses saw up the tissue in an oblique motion. Keeping the gonapophyses in opposition to each other in the wound the egg is inserted into the substance of the leaf. Egg deposition appears to be a strenuous process.

No smearing of the faecal matter on the operculum of the egg has been observed. The site of the deposition of the eggs in Tingidae appears to vary from species to species. In the majority of the cases the lower surface is preferred and Heidmann (1911) holds this site as a rule among Tingidae. Weiss (1919), Johnson (1936) and Roonwal (1952) have recorded the maximum egg-laying along the mid-rib while Livingstone (1962 a & b) recorded a maximum number along the leaf margin. *Monanthia* (Sharga, 1955) deposits the eggs in the stem. In *T. buddleiae* the majority of the eggs are deposited in the fairly old leaves and very rarely in the tender leaves, as observed by Johnson (1936) in *Leptobrysa.* Tildon (1949) recorded maximum number of 56 eggs, laid by a female within four days, deposited both on the dorsal and ventral surfaces of a leaf. Patel and Kulkarney (1955) recorded 168 eggs deposited by a female bug.

The egg (Fig. 3 and 4) is 0·55 mm. long, 0·22 mm. broad, elliptical glistening white and smooth. Its posterior end is bluntly pointed, a characteristic feature of the Heteropteran eggs that are inserted into the plant tissue (Leston, 1953).

HATCHING

The eggs of *T. buddleiae* hatch ten to twelve days after deposition during the months of March and April. In *Urentius echinus*, the incubation period of 6 days seems to be the lowest among Tingidae (Patel and Kulkarney, 1955). In *Monanthia* it is 7 days in June and 15 days in March (Sharga, 1955) while in *Stephanitis* it is 14 days in March (Tildon, 1949).

When the egg swells, the endochorion projects out through its mouth, lifting up the operculum, that remains attached to the endochorion on one side (Fig. 4). Rhythmic movement inside the endochorion and the five pairs of red ommatidia could be easily detected through the transparent exochorion. Soon, the larva lifts the endochorion high up the mouth of the egg (MTHE) and remains in a slanting position, with its ventral surface facing the leaf. The endochorion breaks at the place where it keeps contact with the operculum and the vertex of the nymph gets exposed, having the cuticular structures folded backward. By gradual rhythmic contractions and expansions at the vertex region, the entire head is pulled out, but the appendages still remian folded. Then the cephalic appendages as well as the cuticular structures expand. By the rhythmic pulsation of the head the fore-legs are pulled out. After gaining full grip on the leaf surface with the freed forelegs, the entire body is pulled out from the endochorion ("ecdycial cuticle"). Pulsation inside the head, (the working of the pharyngeal dilators) goes on and according to Goodchild (1952) this results in the sucking of the air into the midgut. It is interesting to note, that, during hatching, the minute processes or serrations of the exochorion of the neck region of the egg grip the endochorion so as to prevent it from coming out entirely and thus aiding easy hatching. After hatching, the endochorion, retaining its grip through these processes with the exochorion, comes out through the mouth of the egg, having the operculum attached to its side.

The whole process of hatching takes about 15-18 minutes. The glistening, white nymph straightens its limbs and soon walks about on the under surface of the leaf for about half an hour, finds a suitable spot at the side of the mid-rib and takes rest. It does not begin feeding until about 1-1½ hours after emergence. Once it starts feeding, it feeds constantly and the alimentary canal is clearly visible as a greenish tube.

IMMATURE STAGES OF T. BUDDLEIAE

There are five nymphal instars (Figs. 5-9), each stadium lasts about two to three days during March and April. The first and last nymphal instars moult after three days while the intermediate instars after two days (Table 3). Patel and Kulkarney (1955) recorded the stadial period as 1·96 days for the first instar and 2·27 days for the last instar, while Tildon (1949) recorded 5 days for first instar and 2 days for the last instar. In the majority of the Tingidae, the average stadial period appears to be three days.

Types of cuticular structures found in the last instar nymph (Fig. 10a-g) are:—

1.	Quadri-radiate scoli.	(a)
2.	Simple short spine	(b)
3.	Simple long spine	(c)
4.	Simple tuberculated spine	(d)
5.	Biramus tuberculated spine	(e)
6.	Simple tubercle	(f)
7.	Biramus tubercle	(g)

All the nymphal instars are translucent and feed along the mid-rib and veins. Congregation of the immature stages is not as significant as it is in the case of *Urentius* sp. (Livingstone, 1959). The cuticular structures of *T. buddleiae* do not show any globulated, waxy secretion as is found in the case of the summer forms like the *Urentius* spp., *Monosteira minutula*, and *Cadmilos retiarius* (Livingstone, 1959; 1962 a and b). But the cuticle of *T. buddleiae* appears shining and to a certain extent sticky, for the sand grains stick to it. The tubercles increase in length in proportion to the growth of the various instars. In the first instar, the spines are longer than those borne by the tubercles of the fifth instar. Transference of the tubercles of the mesothorax, metathorax and first four abdominal segments to the lateral margins of the mesothoracic wing pads (WP) is significant. This phenomenon, termed as "translocation" by Stusak and Stys (1959) is characteristic of Tingidae. The tubercles are body processes with the dermal epithelium in them and are supplied by a fine branch of trachea (Fig. 11 TBT) from the spiracular trunk (SPT).

The spinous body processes or the "immaginifugal" of Stusak and Stys (1959) have been considered by Steidenstücker (Stusak and Stys, 1959) as of very primitive character, retained by most of the adult Tingids as the cephalic tubercles. These cephalic tubercles in *Tingis buddleiae* mark the boundaries of the cephalic areas.

The median dorsal, yellowish, abdominal scent glands with dark brown external openings (OASG) are well pronounced.

All the nymphal instars, about half an hour before ecdysis, stop feeding, select a suitable place, preferably away from the mid rib and remain motionless, with their heads drooping and antennae raised. The cervical membrane becomes prominently transparent and the ecdysial cleavage line (Figs. 5-9 ECDL) extends from the compound sulcus (CS) to the first, median, dorsal abdominal scent gland (MDAG). The cervical region shows rhythmic pulsation and suddenly the cuticle, along the ecdysial cleavage line, breaks, exposing the thorax. The thorax emerges out first and then the head. After getting the forelegs free, the abdomen as well as the cephalic appendages are pulled out of the ecdysial cuticle. When the head is emerged, the rhythmic contraction of the pharyngeal dilators could be easily counted to be at the rate of about 200 strokes per minute. The whole process of ecdysis takes about 15 to 25 minutes. Feeding does not take place for about half an hour after the emergence. Fresh nymphs may select a new spot on the same leaf or may invade other fresh leaves and thus the entire development cycle is not generally completed on a single leaf as it is in the case or *Urentius euonymus* Livingstone, 1959).

KEY TO THE NYMPHAL INSTARS

1. Wing pads not formed; cephalic median tubercle (clypeal) paired and uniramus; bucculae (stipetal lobe) not formed..........2

   Wing pads formed; cephalic median tubercle (clypeal) single and biramus; bucculae (stipetal lobe) formed..............3

2. Eyes with five red ommatidia; rostrum reaching up to the third abdominal segment..............................FIRST INSTAR.

   Eyes with ten to twelve ommatidia; rostrum reaching not beyond the metathorax.. ....SECOND INSTAR.

3. Wing pads do not extend beyond the first abdominal segment; eyes, with not more than eighteen compact ommatidia; prothoracic posterior extension not reaching beyond the anterior half of mesothorax. ......THIRD INSTAR.

   Wing pads extend beyond the first abdominal segment; eyes with more than eighteen compact ommatidia; prothoracic posterior extension extends beyond the mesothorax..................4.

4 Wing pads extend up to the anterior half of the second abdominal segment; prothoracic posterior extension extends up to the anterior half of mesothorax..........................FOURTH INSTAR.

Wing pads extend up to the fifth abdominal segment; acutely convex prothoracic posterior extension reaching up to the middle of metathorax.................... FIFTH INSTAR.

BEHAVIOUR

Tingis buddleiae occasionally performs flights in circles from a higher to a lower level. Occasional fluttering of the wings, prior to feeding, flying and mating is observed as in *Rhinocoris* (Odhiambo, 1959) and Cacao Capsid (Goodchild, 1952). It is interesting to note that during the time when stray cases of insects were observed on the shrub, the slightest disturbance drives the bugs to the soil to hide under leaves and stones. Congregation of adults within the crinkles of leaves during winter is significant. Hibernation of the adults of the second brood and a few other adults has been recorded by Weiss and Dickerson (1918 a and b) in *Corythuca pergandei* and *Corthuca par.hleyi.* Johnson (1936), however, does not find any survival of adults after winter and further recorded the mortality of adults in the act of oviposition early in winter. In many other tingids the winter is passed in the egg stage (Dickerson and Weiss 1917). In *T. buddleiae* neither hibernation nor aestivation is strictly adhered to, as the insect is found both during winter and summer.

Although no marked parental care, as in other species of Tingidae (Dodd, 1904) and *Rhinocoris* (Odhiambo, 1959), has been exhibited by *T. buddlieae,* the congregation of the immature stages along the sides of the midrib and occasional surveying by the adults are common sight.

PREDATORS

A couple of Hymenopterous egg parasites, belonging to the families Mymaridae (Southweed and Scudder, 1956) and Trichogrammatidae (Livingstone, 1962 a) have been recorded so far on Tingid eggs. Besides, many predators like *Coccinella,* Odonata and Acarinid have also been recorded. In *T. buddleiae* no egg parasite has been observed, but the following predators are very commonly found.

1. *Appolodotus* sp. (Heteroptera : Capsidae) (Fig. 12) has been found sucking the body fluids of the adult *T. buddleiae.* However, they are not found in as abundance as they are among *Stephanitis typicus. Dictyla sufflata* and *Corythauma ayyari,* as observed by the author, where they breed on the same leaf on which the Tingids breed and both adults and nymphs predate on the tingid nymphs and adults.

2. An unidentified mite (Figs. 13 and 14) has been found attached to the back of the last nymphal instar and to suck its body contents. A similar acaranid belonging to the genus *Leptus* has been recorded, predating on *Camilos retiarius* (Livingstone 1962 b).

3. An unidentified spider, that simulates the flower bud of the inflorescense of *Buddleia asiatica* remains constantly on the inflorescence feeding on Tingid adults.

4. Larvae of Chrysopa sp. (Neuroptera) (Fig. 15) are found moving along the under surface of the leaves when the population of these bugs is high. The casts of the nymphs stick to the long-hooked hairs (HSP) of the larvae and comouflage the predator. It feeds on the nymphs only.

5. The adults and larvae of *Coccinella* spp. are also found predating on both nymphs and adults during heavy infestation.

SUMMARY

Tingis buddleiae is a sap sucker of *Buddleia asiatica* and *Buddliea madagascarensis* of the family *Loghaniacea.* The population pattern appears to be cyclic. The smooth white eggs are inserted into the substance of the leaf, mostly along the side veins, and the under surface of the leaf. Incubation period is about 12 days. The five nymphal instars differ in the addition of extra complicated cuticular structures. The predators are *Appolodots* sp. (Capsidae); an Acarinid sp; a spider and the larvae of Chrysopa sp. (Neuroptera) and *Coccinella* sp.

REFERENCES

1. Crosby, C.R. & Hadley. 1915. On the Rhododendron lace bug *Leptobrysa explanat* Heidmann. *J. Econ. ent* , **8** : 409-414.
2. Dickerson, E. L. & Weiss, H. B. 1917. The Azalea lace bug *Stephanitis pyrioides* scott. *Ent. News,* **28** : 101-105.
3. Dickerson, E. L. & Weiss, H.B. 1916. Notes on *Leptoypha mutica* (Say). *Ent. News,* **27** : 308-310.
4. Dodd, F.P. 1904. Notes on the maternal instinct in Rhychota. *Trans. ent. Soc. London,* 1904: 483-485.
5. Drake, C. J. 1928. *Tingis (Caenotingis) beesoni,* nymphal stages. *Entomologist.* London **88** : 284.
6. Drake, C. J. 1950. A new species of Tingis from Philippines, *Proc. Washington Acad. Sci.,* **32** : 168.
7. Goodchild, A. J. P. 1952. A study on the digestive system of the West African Cacao Capsid Bugs (Hemiptera : Miridae) *Proc Zool. Soc. London,* **122** : 543-572.
8. Heidmann, O. 1911. Some remarks on the eggs of North American species of Hemiptera: Heteroptera. *Proc. ent. Soc. Washington,* **13** : 128-140.
9. Johnson, C. G. 1936. The biology of *Leptobrysa rhododendri* Horwath. *Ann. appl. biol. Cambridge,* **23** : 342-368.
10. Leston, D. 1953. The eggs of Tingidae, especially *Acalypta Parvula. Ent. Mon. Mag London,* **89** : 132-134.
11. Leston, D.; & Pendergrast, T. G. & Southwood, T. R. E. 1954. classification of the terrestrial Heteroptera (Geocorisae). *Nature,* London, **174** : 91-92.
12. Livingstone, D. 1959. On the bionomics and immature stages of *Urentius euonymus Dist.* (Heteroptera: Tingidae) a sap sucker on the Hollyhock and other garden plants. *Proc. I st. all India Cong. Zool.* Part 2 : 510-519.
13. Livingstone, D. 1961. On the incidence of Tingid population in Agra, India. *Agra Univ. J. Res. (Sci.),* **X** (II) : 187-192.
14. Livingstone, D. 1962. On the biology and immature stages of a sap sucker on *Ziziphus jujuba, Monosteira minutula* Montandon, a species new to India (Hemiptera: Tingidae). *Agra Univ. J. Res. (Sci.),* **XI** (I) : 117-130.

15. Livingstone, D. 1962. On the biology and immature stages of *Cadmilos retiarius* Dist. (Heteroptera: Tingidae) a sap sucker on Compositae. *Agra Univ. J. Res. (Sci.)*, **XI** (III) : 47-62.

16. Livingstone, D. 1962. Tingidae of Western U. P., India. (Hemipterea : Heteroptera) *J. Bombay nat. hist. Soc.*, **59** (1) : 313-316.

17. Odhiambo, T. R. 1959. An account of parental care in *Rhinocoris albopilosus* Signoret (Hemiptera: Heteroptera: Reduviidae) with notes on its life history. *Proc. R. ent. Soc. Lond.*, (a) **34** : 10-12.

18. Patel, R.C. & Kulkarni, H.L. 1955. Bionomics of *Urentius echinus* Dist. Hemiptera: Heteroptera Tingidae, an important pest of Brinjal (*Solanum melangena*) in north Gujarat. *J. Bomay nat. hist. Soc.* **53** (1) : 86-96.

19. Roonwal, M.L. 1962. The natural establishment and dispersal of an imported insect in India, the Lantana bug (*Teleonemia scrupulosa*) Stal. (Lantanae Dist.) (Hemiptera; Tingidae), with a description of its eggs, nymphs, and adults. *J. Zool. Soc. India*, **4** (1) : 1-16.

20. Sharga, U.S. 1955. Bionomics of *Monanthia globulifera* Walker (Hemiptera : Heteroptera : Tingidae). *J. Bombay nat. Hist Soc.*, **51** (4) : 885-889

21. Southwood, T.R.E. & Scudder, G.G.E. 1956. The bionomics and immature stages of Hemiptera : Heteroptera associated with the stinging nettle (*Uritica diocida* L.) *Ent. mon. mag.*, **2** : 313-325.

22. Southwood, T.R.E. & Scudder, G.G.F. 1956. The bionomics and immature stages of the Thistle Lace bug (*Tingis ampliata* H. S. and *T. cardui* L., Hemiptera: Tingidae) *Trans. Soc. Brit. Ent.* **12**: 93-112.

23. Southwood, T.R.E. 1956. The structure of the eggs of the terrestrial Heteroptera and its relationship to the classification of the group. *Trans. R. ent. Soc. London.*, **108** (6) : 133-221, 13 Figs.

24. Stusak, J. M. 1957. A contibution to the knowledge of some last nymphal instars of the Czechoslovakian lace bugs (Hemiptera: Heteroptera: Tingidae). *Acta. Soc. Ent. Czechoslovia.*, **54** : 132-141, 15 figs.

25. Stusak, J. M. & Stys, P. 1959. Investigations on the taxonomy and morphology of imagines and nymphs of some species of the genus, *Monánthia* Le Pelatier et Serville 1825 (hemiptera: Heteroptera: Tingidae). *Acta. Univ. Carolanae Biologica*, **3** : 177-205.

26. Tildon, J. W. 1949. Oviposition and hatching of *Pselliopus spinicollis* Champlin (Heteroptera: Rediviidae). *Pan Pacific Ent.*, **25** : 171.

27. Tildon, J. W. 1949 *Corythucha morilli* (Tingid). *Ent. News.*, Lancaster, **61** : 135-137.

28. Weiss, H. B. & Dickerson, E. L. 1918. The early stages of *Corythucha pergandei* Heid., *Entomological News* **29** : 205.

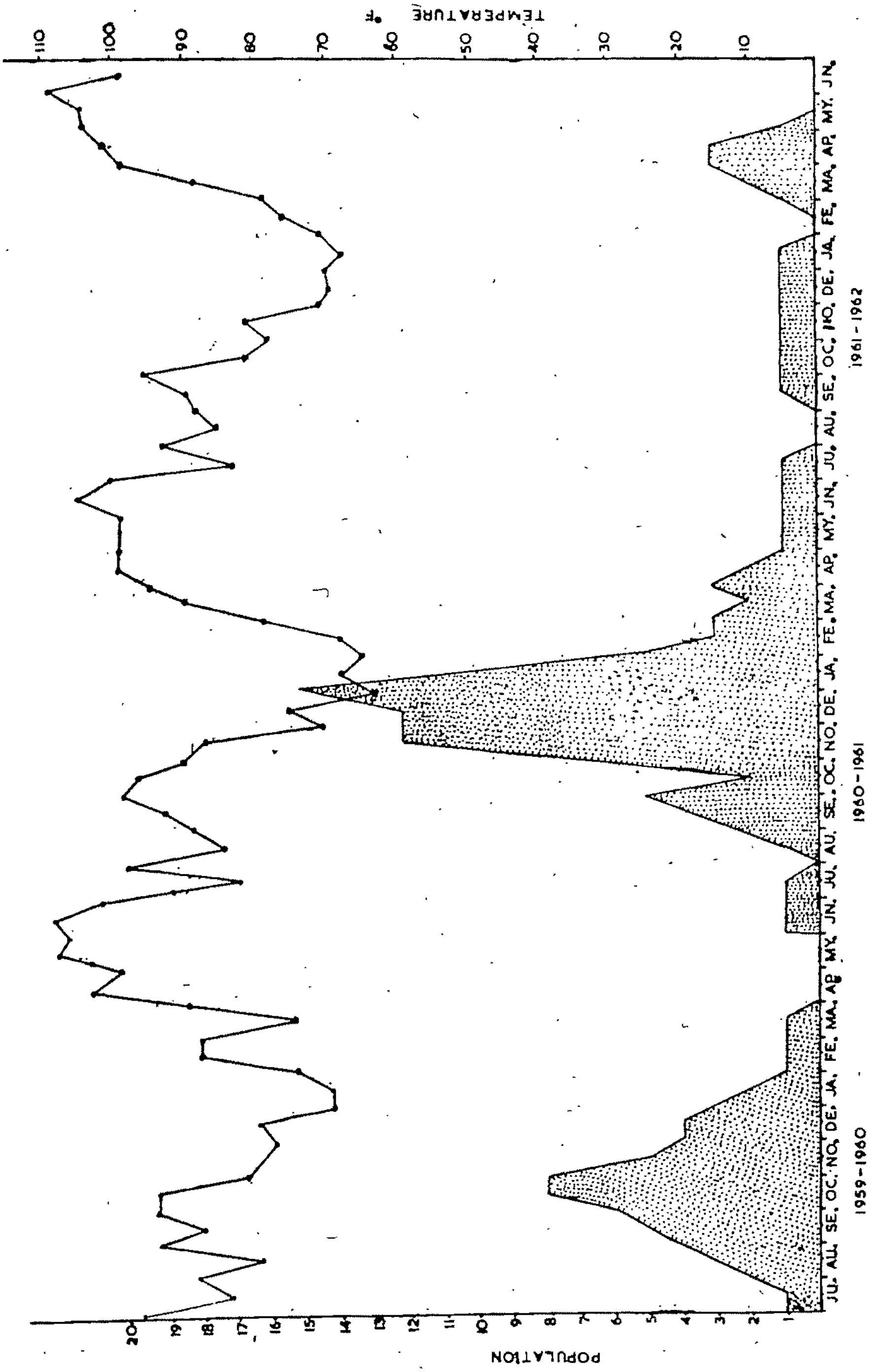
29. Weiss, H. B. & Dickerson, E.L. 1918. The life history and the early stages of *Corythuca parshley* Gibson. *Canadian Entomologist*, 40-50 : 401-406.

30. Weiss, H. B. 1919. Notes on the *Gorgaphifia tiliae* Walsh, Linden lace Bug. *Proc. biol. Soc. Washington*, **32** : 165-168.

TABLE 1

Population fluctuations of Tingis buddleiae Drake during 1959-1962. Each month is divided into two halves. The figures indicate the average number of adults on ten leaves examined.

Years	July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		March		April		May		June	
1959-1960	1	1	2	3	4	5	6	8	8	5	4	4	3	2	1	1	1	1	0	0	0	0	1	1
1960-1961	1	1	0	1	3	4	5	2	7	12	12	12	15	10	5	3	3	2	3	2	1	1	1	1
1961-1962	1	1	0	0	0	1	1	1	1	1	1	1	1	1	0	0	1	1	3	3	1	0	0	0



GRAPH—Showing the population fluctuations of *Tingis buddleiae* Drake during 1959 to 1962.

TABLE 2

Eggs deposition site

Leaf No.	Date	No. of eggs on the upper surface of the leaf	No. of eggs on the lower surface of the leaf						Total No. of eggs on the leaf
			Eggs along the midrib	Eggs along the veins			Eggs at the leaf tip	Total on the lower surface	
				Max.	Min.	Total			
1.	10–4–1962	2	2	12	3	39	7	48	50
2.	10–4–1962	1	0	5	2	20	4	24	25
3.	10–4–1962	0	1	2	1	8	3	12	12
4.	10–4–1962	0	2	3	1	16	4	22	22
5.	10–4–1962	1	2	5	2	12	3	17	18

TABLE 3

Duration of each stadium

Date of Isolation of the leaf	Total No. of eggs on the leaf	Date of hatching	Nos.	2nd instar	3rd instar	4th instar	5th instar	Temp.	Humidity
8-4-1962	50	10-4-1962	6	14-4-1962	17-4-1962	19-4-1962	22-4-1962	68°F.	28%
		11-4-1962	2	14-4-1962	16-4-1962	19-4-1962	22-4-1962	,,	,,
		12-4-1962	15	15-4-1962	17-4-1962	20-4-1962	23-4-1962	,,	,,
		13-4-1962	5	16-4-1962	19-4-1962	21-4-1962	24-4-1962	,,	,,
		14-4-1962	5	17-4-1962	19-4-1962	22-4-1962	25-4-1962	,,	,,
		15-4-1962	3	18-4-1962	20-4-1962	23-4-1962	26-4-1962	,,	,,
		16-4-1962	5	19-4-1962	21-4-1962	24-4-1962	27-4-1962	,,	,,
		17-4-1962	5	19-4-1962	22-4-1962	24-4-1962	27-4-1962	,,	,,

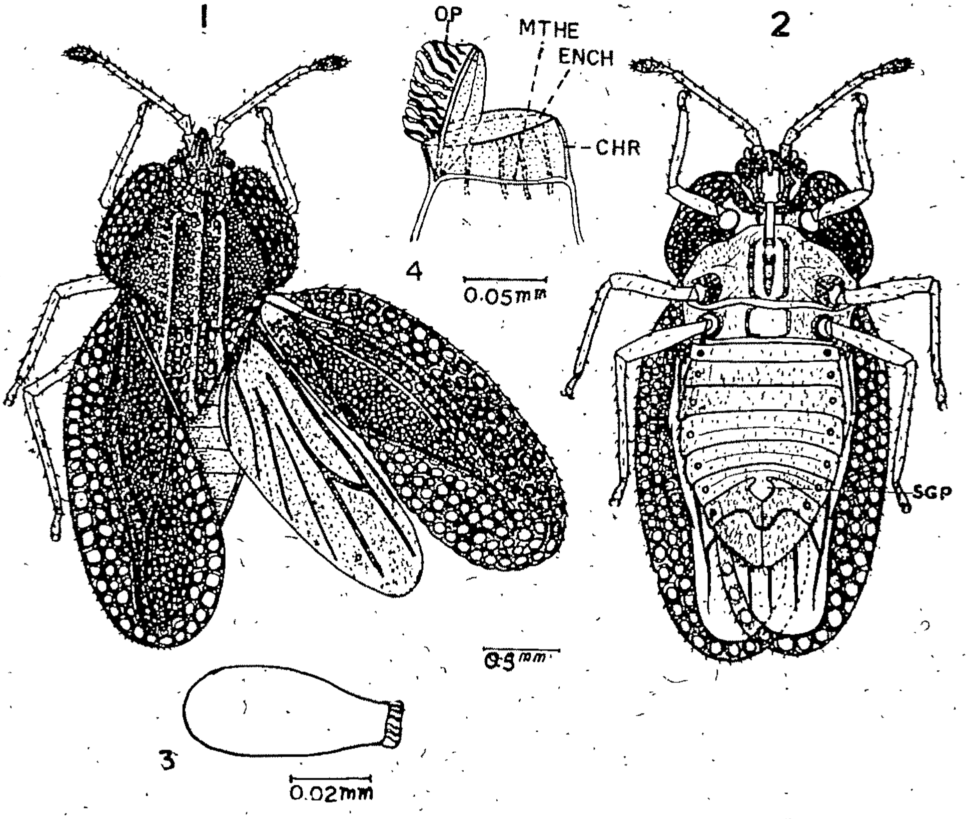


Plate 1

Figs. 1 & 2. *Tingis buddleiae* Drake.
Fig. 3. The egg.
Fig. 4. The cephalic end of the egg at the time of hatching.

CHR-Chorionic rim; ENCH—Endochorion; MTHE—Mouth of the egg; OP—Operculum; SGP—Sub-genital plate.

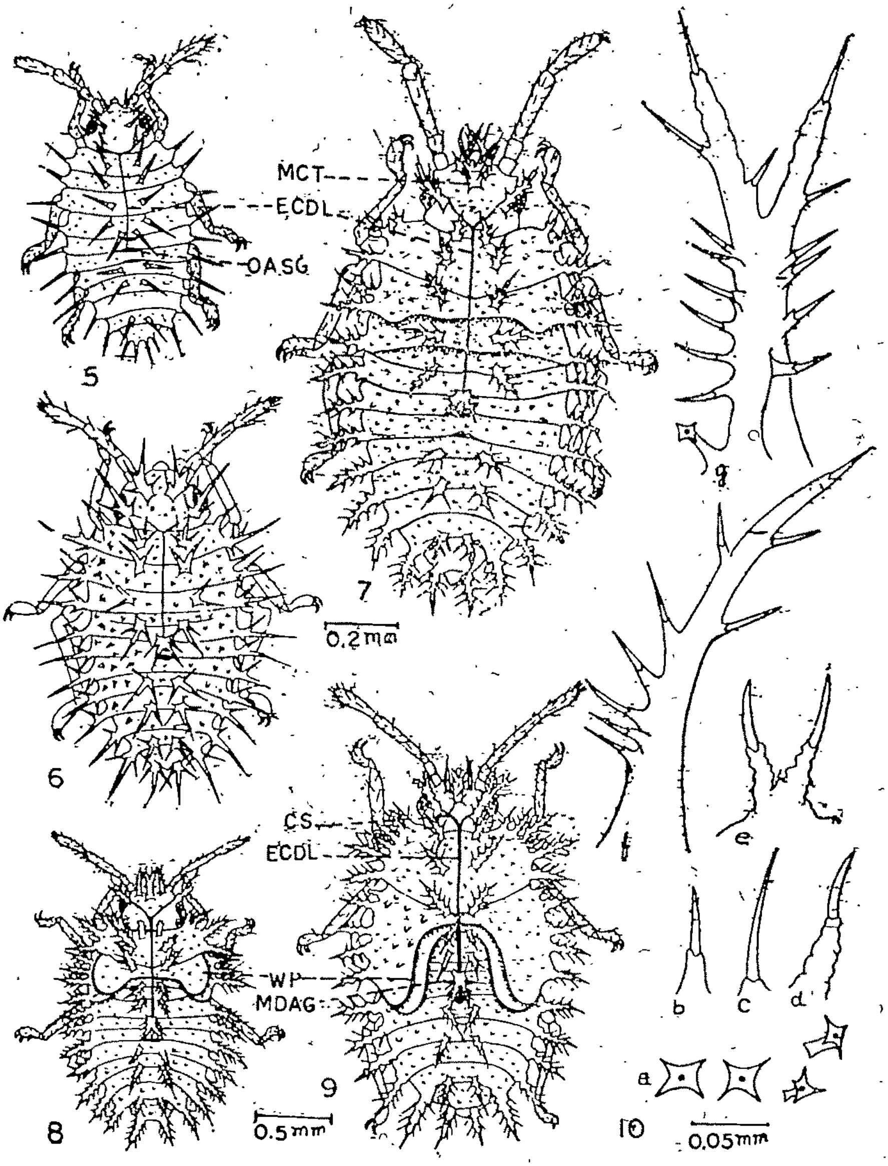


Plate 2

Figs. 5—9. The first, second, third, fourth and fifth nymphal instars.

Fig. 10. Various types of cuticular structures found on the fifth nymphal instar.

a—Quadriradiate scoli; b—Simple short spine; c—Simple nontuberculated long spine; d—Simple tuberculated spine; e—Biramus tuberculated spine; f—Tubercle of the lorum; g—Biramus tubercle; CS—Compound sulcus; ECDL—Ecdysial cleavage line; MCT-Median cephalic tubercle; MDAG'-First median abdominal scent gland opening; OASG-Second median abdominal scent gland opening; WP—Wing pad.

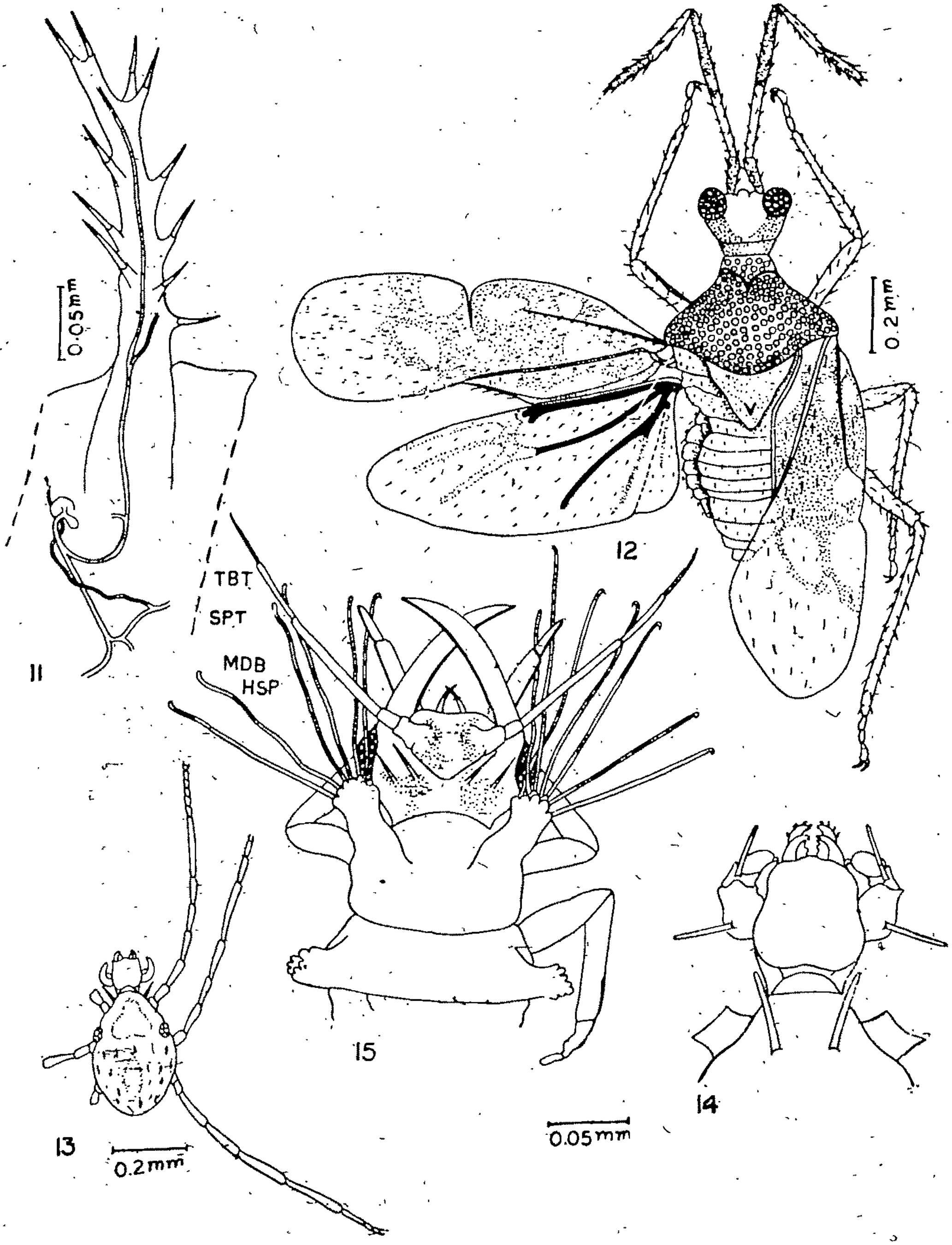


Plate 3

Fig. 11. Tubercular tracheation.
Fig. 12. Predator, apollodotus SP. (Capsidae).
Fig. 13. Acarinid ectoparasite.
Fig. 14. Cephalothoracic region of the acarinid.
Fig. 15. Anterior region of the larva of *Chrysopa* sp. (Neuroptera)

MDB—Mandible: HSP—Hooked spines: SPT—Spiracular trunk; TBT—

COMPARATIVE STUDY OF STEADY HYDROMAGNETIC FLOW OVER CONDUCTING AND NON-CONDUCTING PLANE WALLS IN PRESENCE OF A TRANSVERSE MAGNETIC FIELD

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INTRODUCTION

In the present paper is studied the distribution of Velocity Vx, induced Magnetism Hx and electric current density Jy for various values of Magnetic pressure no. S when magnetic Prandtl no. $Pm = 1$ and for various values of Pm when $S = 0{\cdot}5$.

The theory of flow of electrically conducting, incompressible viscous fluid of constant electric and magnetic properties between parallel (non conducting and non-porous) walls in the presence of a uniform transverse magnetic field known as Hartman Flow Problem is now a text-Book work (*e.g.* cowling)[1]. The theory of Flow through ducts of rectangular and circular cross-section was considered by Shercliff (1953, 1955, 1956 *a,b,c*)[2], Uflyand[3] (1960) and Chang and Lundgren[4] (1961). Shercliff (1953) gave an exact solution of the modified Navier-stokes equations governing the steady flow in question for the rectangular case with non-conducting walls, the magnetic field Ho being perpendicular to the two walls. Chang and Lundgren (1961) considered the effect of perfectly conducting walls on the flow in rectangular and circular ducts and they inferred that increasing the wall conductivity decreases the velocity. Gupta[5] (1960) treated the problem of flow past a non-conducting porous plane wall (for both cases of suction and injection). Due to some inconsistencies in his paper, the problem was again taken by Kakutani[6] (1961) who showed that no steady solution can be obtained for the case of injection. However, for the case of uniform suction, he obtained an exact solution for the steady state when $S \angle 1$. The stationary flow of a conducting fluid in channels with non-conducting porous walls was described by Agarwal and Agarwal[7] (1963) and Agarwal[8] (1963). Ray and Agarwal[9] (1964) in their two papers obtained solution to the problem of the steady hydromagnetic flow over a perfectly conducting infinite plane wall with uniform suction in the presence of a transverse Magnetic field. All physical quantities are assumed to be functions of the transverse space coordinate alone. The author finds that no exact solution exists for the case of uniform injection for all values of S nor for the case of uniform suction for $S \geqq 1$. Analytical expressions have however been derived when $S \angle 1$ in the analysis.

I feel that distributions of Vx, Hx, and Jy for different values of Pm and S may be of interest to Physicists and I have therefore given in this paper the physical characteristics of the solutions of Ray and Agarwal by drawing graphs of the above three distributions—the graphs have been obtained using DD 80 together with CDC 3600 digital computer. Attempt has also been made to provide comparative results obtained by previous authors in particular, for the case of non-conducting walls such as described by T. Kakutani (1961).

EQUATIONS CONSTITUTING THE EXACT SOLUTIONS FOR THE FLOW DISCUSSED BY RAY AND AGARWAL IN THEIR PAPERS

The equations giving the Velocity V_x, induced magnetism H_x and the electric current density J_y for the steady Hydromagnetic flow over a conducting infinite plane wall with uniform suction in the presence of a transverse magnetic field are the following equations(1) to (3):—

$$\frac{V_x}{U} = 1 - \frac{1}{4\gamma\, P_m}\Big[(1+P_m-\gamma)\,(1-P_m+\gamma)e^{\alpha z} - (1+P_m+\gamma)(1-P_m-\gamma)e^{\beta z}\Big] \quad \ldots \ (1)$$

$$\frac{H_x}{H_0} = \frac{U}{2\gamma V_0}\Big[(1+P_m-\gamma)e^{\alpha z} - (1+P_m+\gamma)e^{\beta z}\Big] \quad \ldots \ (2)$$

$$J_y = \mu 6\,(V_0\, H_x - V_x\, H_0) \quad \ldots \ (3)$$

$$\text{where } \alpha,\ \beta = \frac{V_0}{2\nu}\Big[(1+P_m) \pm \sqrt{(1-P_m)^2+4\ S\ P_m}\Big] \quad \ldots \ (4)$$

$$\gamma = \sqrt{(1-P_m)^2+4\,S\,P_m} \quad \ldots \ (5)$$

ν is the Kinematic coefficient of Viscocity and 6 is the electrical conductivity of the fluid.

Since I have assumed all physical quantities to be the functions of space coordinate Z alone, I draw graphs for the three required distributions as detailed below. When $S \angle 1$, both α and β are negative, hence from (4) above, it is clear that in the graphs of three distributions $\frac{-V0}{\nu}$ should be taken as the coefficient of Z since the three distributions (1) to (3) involve α and β:—

1. (*a*) $\frac{V_x}{U}$ *vs.* $-\frac{-V_0 Z}{\nu}$ for $P_m=1{\cdot}0$, $S={\cdot}25, {\cdot}50, {\cdot}75$

with wall conductivity $6_w=0$ and $6_w=\alpha$

(*b*) $\frac{V_x}{U}$ *vs.* $\frac{-V_0 Z}{\nu}$ for $S=0{\cdot}5$, $P_m={\cdot}5, 1{\cdot}0, 2{\cdot}0$

with wall conductivity $6_w=0$ and $6_w=\alpha$

2. (*a*) $-\left(\frac{V_0\, H_x}{U H_0}\right)$ *vs.* $-\frac{V_0 Z}{\nu}$ for $P_m=1{\cdot}0$, $S={\cdot}25, {\cdot}50, {\cdot}75$

with wall conductivity $6_w=0$ and $6_w=\alpha$

(*b*) $-\left(\frac{V_0\, H_x}{U H_0}\right)$ *vs.* $-\frac{V_0 Z}{\nu}$ for $S={\cdot}5$, $P_m={\cdot}5, 1{\cdot}0, 2{\cdot}0$

with wall conductivity $6_w=0$ and $6_w=\alpha$

3. (*a*) $J_y/6\mu\, UH_0$ *vs.* $\frac{-V_0 z}{\nu}$ for $P_m=1{\cdot}0$, $S={\cdot}25, {\cdot}5, {\cdot}75$

with wall conductivity $6_w=0$ and $6_w=a$

(*b*) $J_y/6\mu\, UH_0$ *vs.* $\frac{-V_0 z}{\nu}$ for $S={\cdot}5$, $P_m={\cdot}5, 1{\cdot}0, 2{\cdot}0$

with wall conductivity $6_w=0$ and $6_w=a$.

INTERPRETATIONS FOR THE GRAPHICAL RESULTS

1. (*a*) The graph shows that for the fixed magnetic Prandtl number $Pm=1$, the velocity rise as one goes away from the infinite conducting plane is slower in the case of perfect conductivity of the wall than the case of no conductivity of the wall. This is so in all the cases of the plotting of magnetic Pressure numbers *i.e.* $S={\cdot}25, {\cdot}50, {\cdot}75$.

It is also clear from the figures that this difference of corresponding velocities depending on the conductivity of the wall goes on reducing with the diminishing values of S *i.e.* the gap between the rise of the two velocities (one for perfectly conducting wall and the other for non-conducting wall) is maximum for $S={\cdot}75$, and minimum for $S={\cdot}25$.

I therefore infer that for fixed Prandtl number, increasing the wall conductivity decreases the velocity for all values of S.

But diminishing the value of S, also affects to neutralise the affect of wall conductivity on Vel. *i.e.* for the lowest value of $S={\cdot}25$, the Vel. profiles $6_w=0$ and for $6_w=a$ almost coincide.

(*b*) For fixed Magnetic press. number *i. e.* $S={\cdot}5$, I have plotted graphs when P_m assumes the values $P_m={\cdot}5, 1{\cdot}0, 2{\cdot}0$.

In this case results are the same as in the case of (*a*) above.

2. (*a*) From the graphs of the distribution

$$-\left(\frac{V_0 H_x}{U H_0}\right) \textit{vs.} -\left(\frac{V_0 Z}{\nu}\right) \text{ for fixed } P_m=1,$$

We see that for non-conducting walls as we move away from the plane, the magnetic field goes on rising upto a certain value of Z and then starts diminishing—of course the fall in the value of Magnetic field is more rapid in the case for $S={\cdot}25$ then for $S={\cdot}75$. The rise in the fields for all values of S is almost the same.

For perfectly conducting wall, the magnetic field is maximum at the plane and its value falls sharply as we move away from the plane—this fall of the value of magnetic field depends on S also as in the case of non-conducting wall.

Thus the obvious facts are that the magnetic field at the plane is maximum for perfectly conducting wall and minimum for non-conducting wall. But in both the cases after a certain distance from the plane the field starts diminishing for all values of $S = \cdot 25$, $\cdot 5$, $\cdot 75$ — of course still after diminishing of the fields, the field is always greater for perfectly conducting wall than for non-conducting wall.

(*b*) In this case for $S = \cdot 5$ (fixed) when P_m assumes the values $P = \cdot 5$, $1 \cdot 0$, $2 \cdot 0$, we see from the graphs that for non-conducting walls, the magnetic fields go on rising upto certain values of Z (which are almost the same for all the 3 cases of $P_m = \cdot 5$, $1 \cdot 0$, $2 \cdot 0$) and then the values of fields fall. Here slightly different from that of the case of 2 (*a*), (for non-conducting walls) the fields take up the rising trend from the plane and rise is in the ascending order *i.e.* lowest for $P_m = \cdot 5$ and greatest for $P_m = 2$ unlike that for the case of fixed P_m with variable S when magnitude of magnetic fields in the three cases was almost the same.

All other interpretations are same as in the case of 2 (a) 3 (*a*). From the graph (5) wherein I have assumed $P_m = 1 \cdot 0$ and $S = \cdot 25$, $\cdot 5$, $\cdot 75$, I find that in the case of non-conducting walls as we move away from the plane, the current-density increases from the Zero-value to the maximum value for certain value of Z and then it becomes almost steady for all the values of Z irrespective of the different values of S.

In the case of perfectly conducting walls, the current density is of significant value at the plane itself and then it slowly increases as we move away from the plane and becomes steady for approximately the same value of Z for which it assumed a similar character in the case of non-conducting walls.

Actually after a certain value of Z, the values of current densities in the cases of non-conducting walls and conducting walls, maintain the same ratio in regard to their steadiness.

Thus I infer that wall conductivity increases the current density under all circumstances.

3 (*b*) When I keep $S = \cdot 5$ (fixed) and P_m assumes the values $P_m = \cdot 5$, $1 \cdot 0$, and $2 \cdot 0$ I find the same results as in the case of 3(*a*).

ACKNOWLEDGEMENT

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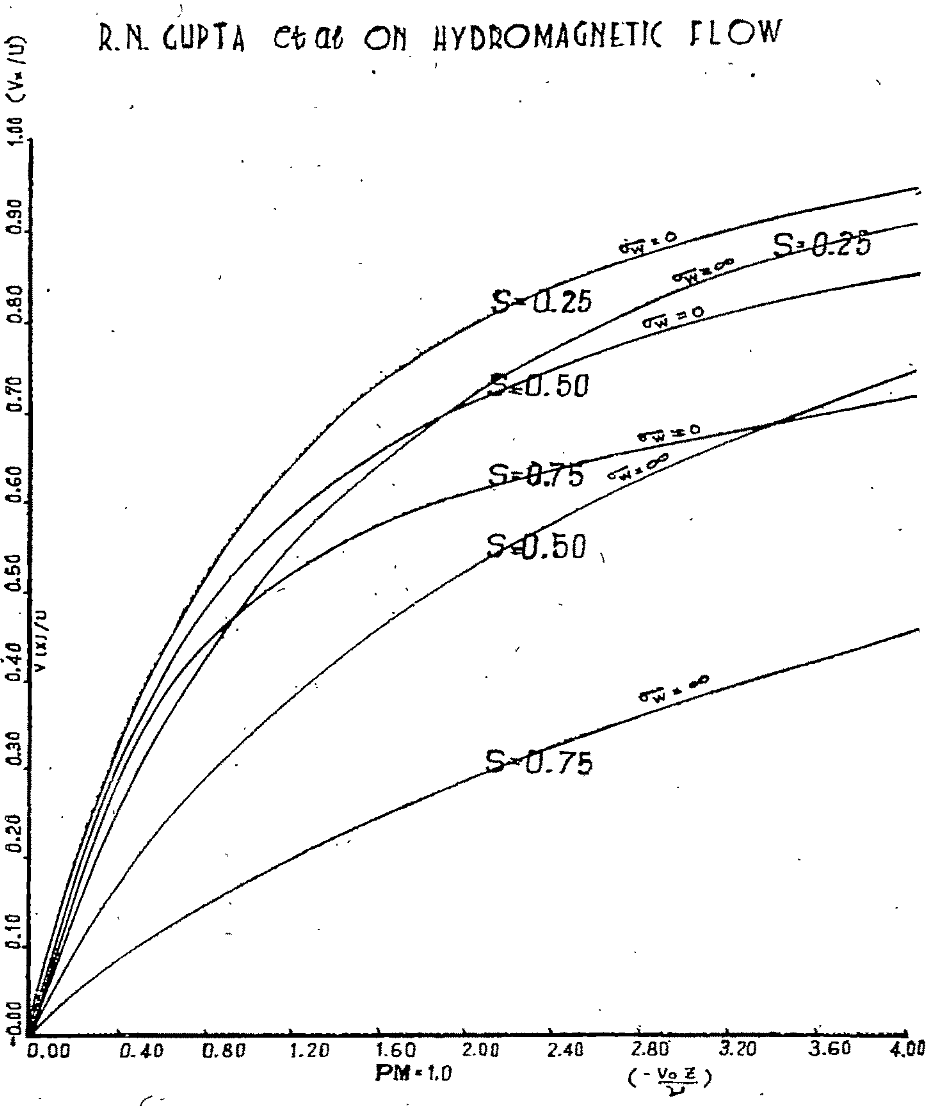
REFERENCES

1. Cowling, T. G. 1957. Magnetohydrodynamics (Inter Science Publishers, Inc., New York, p. 13.
2. Shercliff, J.A. 1953. *Proc. Camb. Phil. Soc.*, **49**, 136.
3. Shercliff, J.A. 1955. *Proc. Royal Soc.* A, 233, 396.
4. Shercliff, J.A. 1956a. *J. Fluid Mech.* **1**, 644.

5. Shercliff, J.A. 1956b. *Proc. Camb. Phil. Soc.*, **52**, 573
6. Shercliff, J.A. 1956c. *J. Nucl. Energy*, **3**, 305
7. Ulfyand, Ya. S. 1960. *Zh. Tekh Fiz* **30**, 1258
8. Chang, C.C. & Lundgren, T.S. 1961. *Z, Angew. Maths. Phys.* **12**, 100
9. A.S. Gupta 1960. *Z. Angew, Maths. Phys.* **11**, 43–48
10. T. Kakutani 1961. *Z. Angew, Maths. Phys.* **12**, 219–230.
11. Agarwal, K.M. & Agarwal, J.C. 1964. *Agra Univ. J. Res.* (*Sci.*), **XIII** (I) : 57-63.
12. Agarwal, J C. 1963. *Uttara Bharti,* Dec.
13. Ray, M. & Agarwal, J.C. 1964. *Bulletin of Cal. Maths. Soc.* 160–170.
14. Ray, M. & Agarwal, J.C. 1964. *Bulletin of Cal. Maths. Soc.* 171-175.

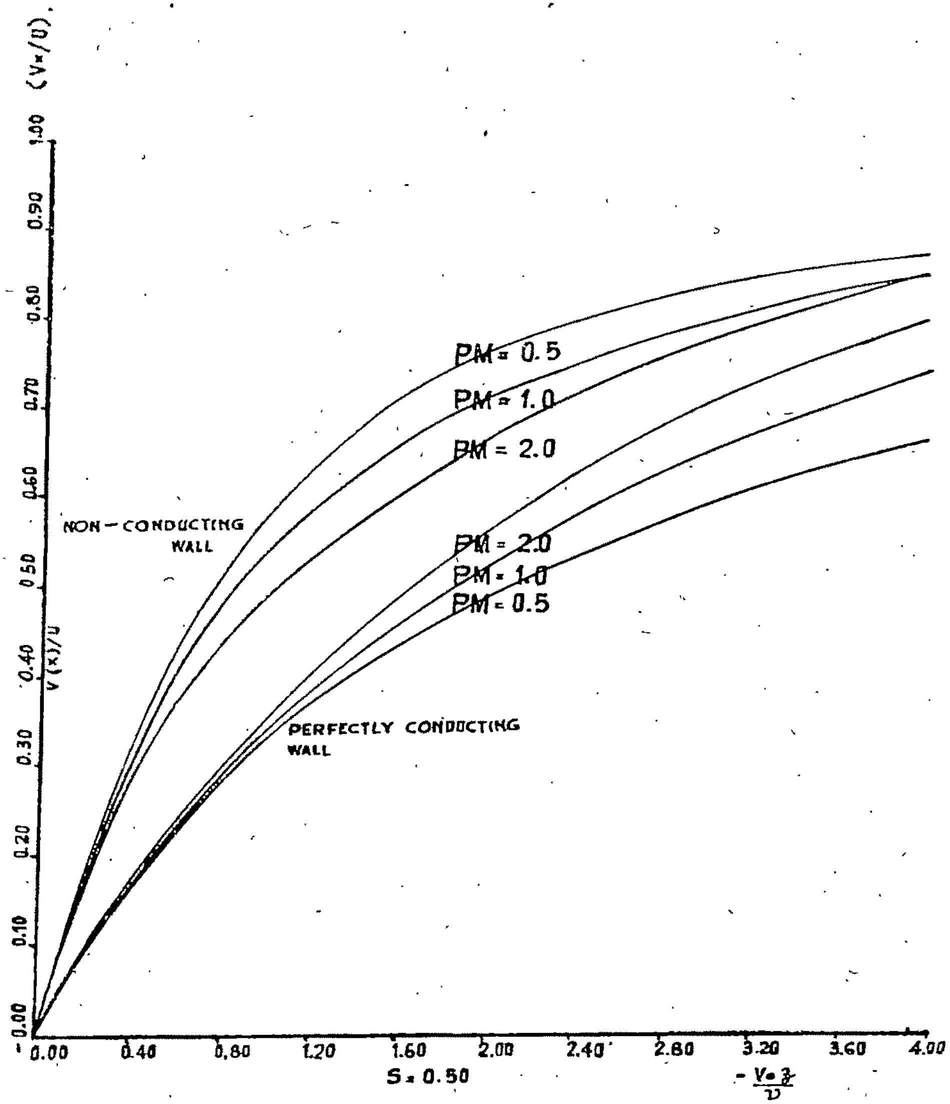


σ_w = Wall - Conductivity

(V_x/U) vs $(-\frac{V_0 z}{\nu})$ for $P_m = 1.0$, $S = \cdot 25, \cdot 5, \cdot 75$

Fig. 1

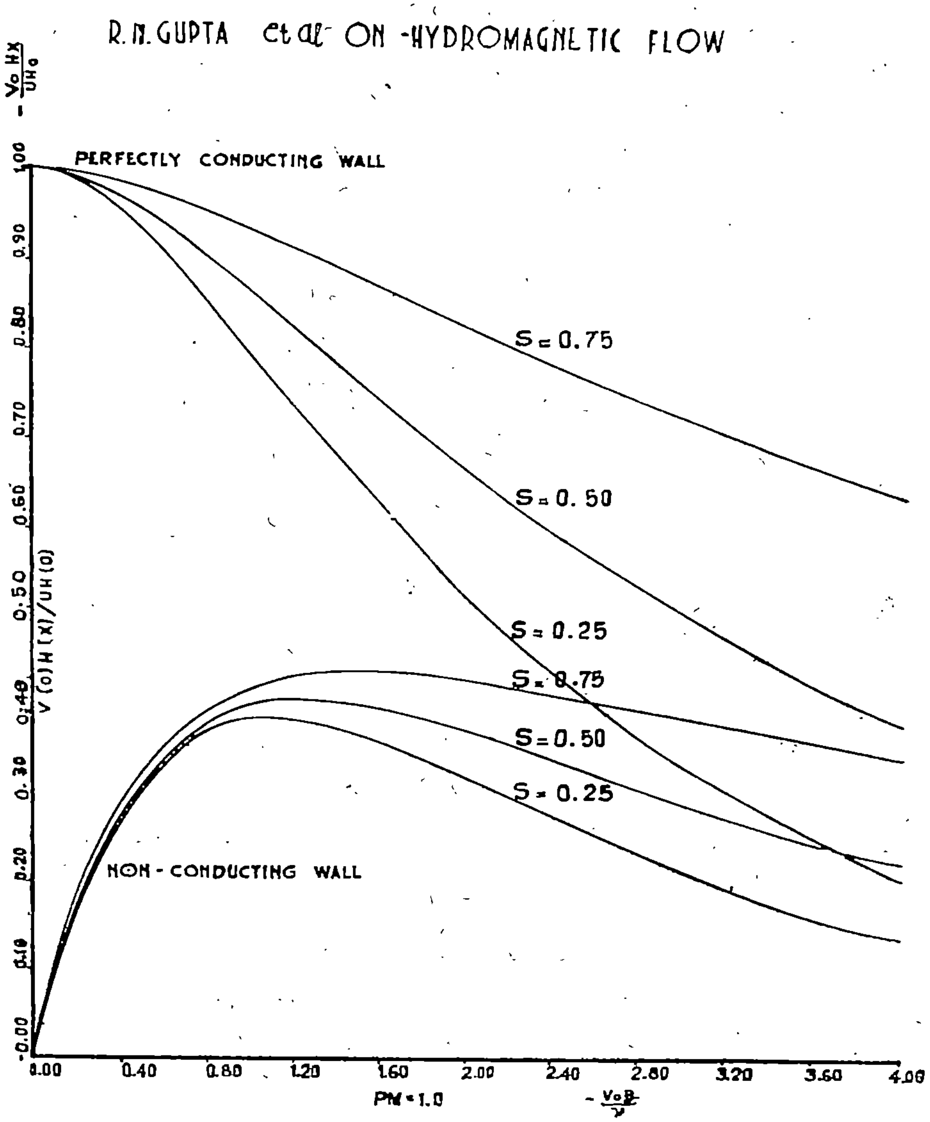
R.N. GUPTA et al ON HYDROMAGNETIC FLOW



PM stands for Pm

(V_x/U) vs $(-V_0 Z/\nu)$ for $S = 0{\cdot}5$. $P_m = {\cdot}5, 1{\cdot}0, 2.0$

Fig. 2

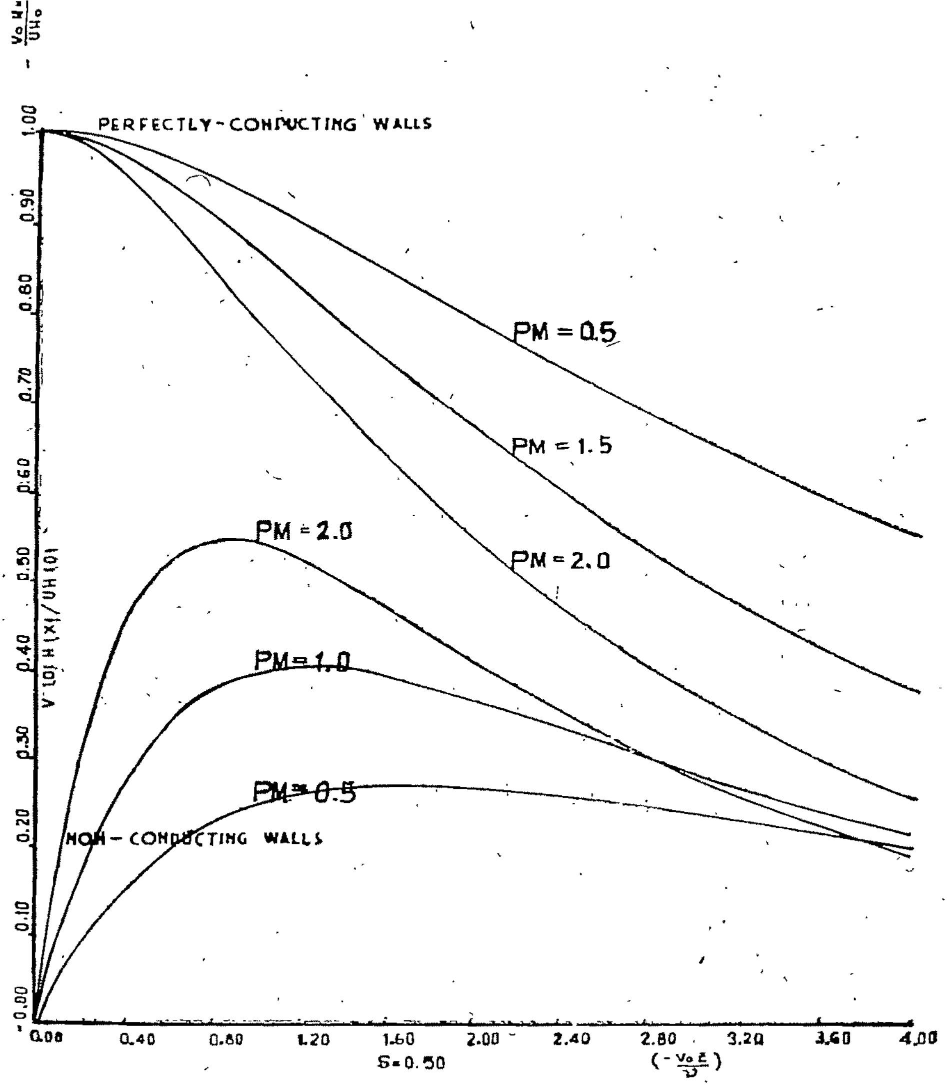


$P_m = 1.0$

$-(V_0 H_x / UH_0)$ vs $\left(-\frac{V_0 z}{\nu}\right)$ for $P_m = 1.0$, $S = \cdot 25, \cdot 75, \cdot 50$

Fig. 3

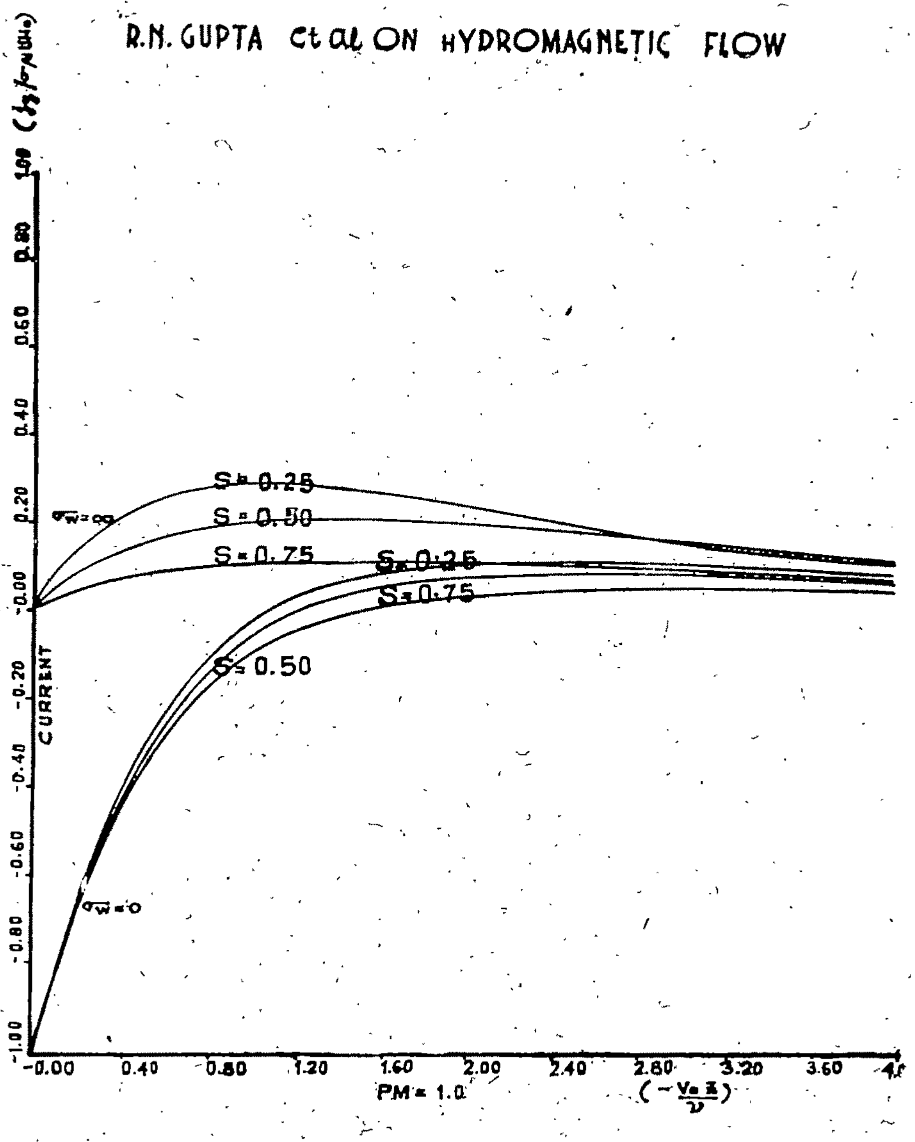
R.N. GUPTA et al ON HYDROMAGNETIC FLOW



PM stands for R_m

$-(V_0 H_x/UH_0)$ vs. $-(V_0 z/\nu)$ for $S = 0.50$, $R_m = .5, 1.0, 2.0$

Fig 4

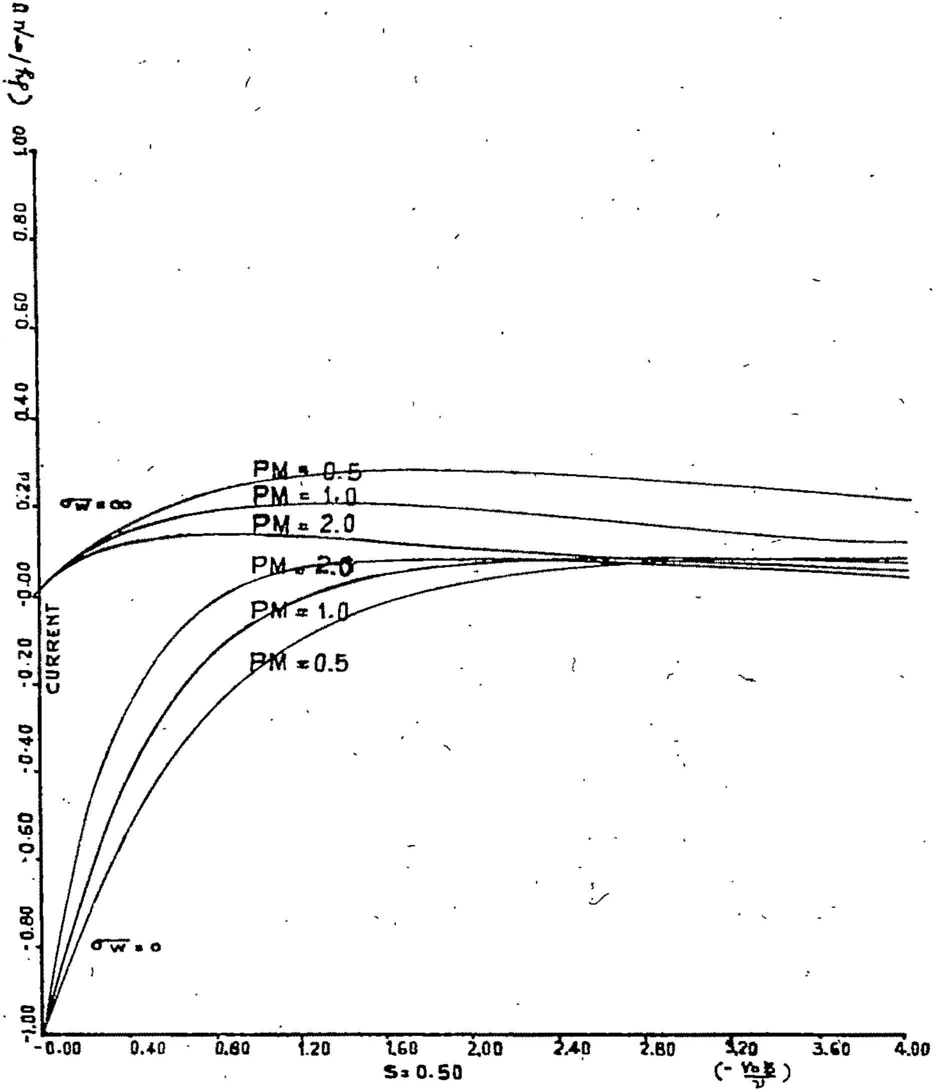


σ_w = Wall - Conductivity

$(j_y/\sigma\mu U H_0)$ vs $(-\frac{V_0 z}{\nu})$ for $P_m = 1.0$, S = ·25, ·75, ·50

Fig. 5

R.N. GUPTA et al ON HYDROMAGNETIC FLOW



$\sigma_{\bar{w}}$ = Wall Conductivity

$(j_y/\sigma\mu UH_0)$ vs $(-\frac{V_0 z}{\nu})$ for S = ·5, Pm = ·5, 1, 2.

Fig. 6

A NOTE ON THE PROCESS OF AMMONIFICATION

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According to Miyake (1916) the process of ammonification and nitrification are autocatalytic chemical reactions. The differential equation for these type of reactions is

$$\frac{dx}{dt} = kx(a-x) \qquad ..(1)$$

Where 'k' and 'a' are constants. This equation expresses the fact that the velocity of transformation is, at any instant, proportional to the amount of substance which is undergoing change and the amount of the substance which has already been transformed.

Integrating equation (1) we get

$$\log \frac{x}{a-x} = akt + c \qquad ..(2)$$

Where 'c' is the constant of integration. In order to get the value of 'c' we put $x = a/2$. Then we have

$$\log \frac{x}{a-x} = ak\ (t-t_1) \qquad ..(3)$$

where t_1 is the time at which the reaction is half completed. This equation may obviously be written as

$$\log \frac{x}{a-x} = k\ (t-t_1) \qquad ..(4)$$

Where 'x' represents the amount of reaction product at the time 't' and 'a' represents the maximum amount of reaction product and 'k' is a constant which can be determined from a known value of 'x' at any given time 't'.

On differentiating equation (1) with respect to 'x' and putting $\frac{dx}{dt} = v$ we get

$$\frac{dv}{dx} = k\ (a-2x) \qquad ..(5)$$

Differentiating again we have

$$\frac{d^2v}{dx^2} = -2k \qquad ..(6)$$

The right hand side of equation (5) vanishes and is negative when $x=a/2$, hence $\frac{dx}{dt}$ is at a maximum when $x=a/2$. In other words, we may say that the rate of increase of reaction products during a given period of reaction should be at maximum when the reaction of that period is half completed.

Miyake applied equation (4) to the results of Lipman *et al* (1912), Lemmermann *et al* (1911) and Warington (1879) and obtained the calculated values in close proximity with their experimental values. The present work was undertaken with a view to test the validity of this equation further for the ammonification of Albumin, blood meal and neem cake.

EXPERIMENTAL

Ammonification was studied in three different normal soils by taking 100 gms of each in duplicate, mixing different nitrogenous substances like albumin (15·50% N), blood meal (12·91% N) and neem cake (5·43% N) supplying 100 mgms of nitrogen and incubating them at optimum temperature and moisture for different intervals of time. After the period of incubation the amount of NH_4-N was estimated colorimetrically by nesselerization.

TABLE 1

Ammonification of Albumin

Equation for soil (i) $\log \frac{x}{82{\cdot}62-x} = {\cdot}1883\,(t-7{\cdot}2)$

,, ,, ,, (ii) $\log \frac{x}{81{\cdot}46-x} = {\cdot}1334\,(t-7)$

,, ,, ,, (iii) $\log \frac{x}{84{\cdot}64-x} = {\cdot}1970\,(t-6{\cdot}6)$

Amount of NH_4-N (mgm) in different soils

Days	Soil (i)		Soil (ii)		Soil (iii)	
	Found	Calculated	Found	Calculated	Found	Calculated
2	7·45	7·88	14·18	14·43	10·23	9·34
4*	16·68	16·50	22·21	23·11	19·79	19·90
6	30·60	30·86	33·79	34·52	36·20	36·64
8*	49·02	48·40	46·60	48·20	57·02	55·32
10	63·06	63·70	57·02	58·27	69·42	69·55
12*	72·20	73·45	66·58	67·02	76·60	77·91
14	77·02	78·50	72·63	72·96	81·01	81·78
16*	80·61	80·86	76·60	78·85	83·37	83·46

N. B.—The days marked * were taken for calculation.

RESULTS AND DISCUSSION

Applying equation (4) in the case of albumin (table 1) we have

$$\log \frac{16 \cdot 68}{(a - 16 \cdot 68)} = k\,(4 - t_1) \qquad ..(i)$$

$$\log \frac{72 \cdot 20}{(a - 72 \cdot 20)} = k\,(12 - t_1) \qquad ..(ii)$$

$$\log \frac{49 \cdot 02}{(a - 49 \cdot 02)} = k\,(8 - t_1) \qquad ..(iii)$$

$$\log \frac{80 \cdot 61}{(a - 80 \cdot 61)} = k\,(16 - t_1) \qquad ..(iv)$$

From (i) and (ii) by subtraction we get:—

$$\log \frac{72 \cdot 20\,(a - 16 \cdot 68)}{16 \cdot 68\,(a - 72 \cdot 20)} = 8k \qquad ..(v)$$

and from (iii) and (iv)

$$\log \frac{80 \cdot 61\,(a - 49 \cdot 02)}{49 \cdot 02\,(a - 80 \cdot 61)} = 8k \qquad ..(vi)$$

From (v) & (vi) we have

$$\frac{72 \cdot 20\,(a - 16 \cdot 68)}{16 \cdot 68\,(a - 72 \cdot 20)} = \frac{80 \cdot 61\,(a - 49 \cdot 02)}{49 \cdot 02\,(a - 80 \cdot 61)}$$

Solving this equation we get $a = 82 \cdot 62$.

The amount of NH_4-N produced is plotted against days (Fig. 1) and from this graph the value of 't_1' is obtained which is 7·2 in this case.

Hence equation (1) for this case becomes.

$$\log \frac{x}{82 \cdot 62 - x} = k\,(t - 7 \cdot 2)$$

Now putting different values of 't', different values of 'k' are obtained and the average value of 'k' is taken, which in this case is found to be 0·1883. Then the above equation becomes

$$\log \frac{x}{82 \cdot 62 - x} = 0 \cdot 1883\;(t - 7 \cdot 2)$$

By substituting different values for 't' corresponding value of 'x' have been calculated.

By similar procedure different equations were obtained for the ammonification of different substances in different soils.

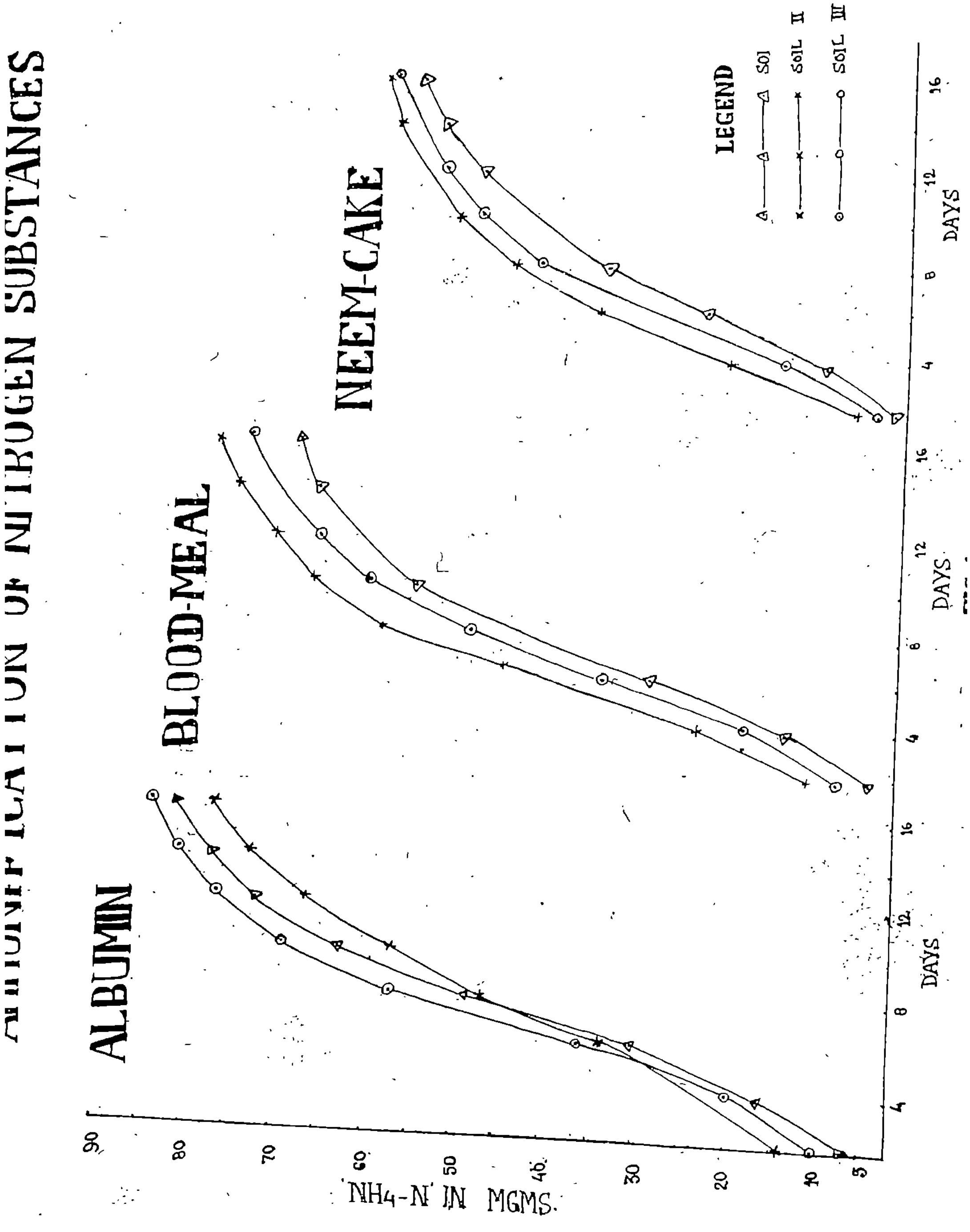
NIFICATION OF NITROGEN SUBSTANCES
ALBUMIN
BLOOD-MEAL
NEEM-CAKE
LEGEND
SOIL I
SOIL II
SOIL III
NH4-N IN MGMS.
90
80
70
60
50
40
30
20
10
5
4
8
12
16
DAYS

TABLE 2

Ammonification of Blood meal

Equation for soil I $\log \frac{x}{70{\cdot}08-x} = {\cdot}1949\,(t-6{\cdot}6)$

,, ,, ,, II $\log \frac{x}{79{\cdot}52-x} = {\cdot}1747\,(t-5{\cdot}8)$

,, ,, ,, III $\log \frac{x}{80{\cdot}20-x} = {\cdot}1762\,(t-6{\cdot}75)$

Amount of NH_4-N (mgms) in different soils

Days	Soil I		Soil II		Soil III	
	Found	Calculated	Found	Calculated	Found	Calculated
2	5·41	7·08	11·80	11·29	8·60	10·18
4*	14·62	15·89	24·22	25·96	19·04	19·79
6	29·78	30·35	51·86	54·94	34·62	34·04
8*	45·38	44·59	55·25	56·28	48·98	50·07
10	56·24	57·56	66·63	67·12	60·96	63·27
12*	61·02	64·37	71·23	73·45	66·20	71·68
14	66·80	67·03	75·35	76·68	73·94	76·17
16*	68·62	69·31	77·78	78·22	74·22	78·36

N. B.—The days marked * were taken for calculation.

TABLE 3

Ammonification of Neem cake

Equation for soil I $\log \frac{x}{58{\cdot}43-x} = {\cdot}1842\,(t-6{\cdot}9)$

,, ,, ,, II $\log \frac{x}{61{\cdot}67-x} = {\cdot}1592\,(t-5{\cdot}2)$

,, ,, ,, III $\log \frac{x}{60{\cdot}41-x} = {\cdot}1927\,(t-6{\cdot}1)$

Amount of NH_4-N (mgms) in different soils

Days	Soil I		Soil II		Soil III	
	Found	Calculated	Found	Calculated	Found	Calculated
2	3·70	6·49	7·91	14·57	5·12	8·42
4*	11·38	13·21	21·55	24·16	15·59	17·07
6	22·60	23·70	36·26	35·32	24·65	23·64
8*	35·21	35·90	45·72	45·40	42·54	42·23
10	43·95	46·06	52·02	52·61	49·86	51·16
12*	49·90	52·40	55·43	56·96	53·75	56·30
14	54·10	55·69	58·40	59·31	56·96	58·64
16*	56·88	57·22	60·40	60·51	59·34	59·67

It is seen from the tables (1, 2, 3) that the observed and calculated values of 'x' are in good agreement. There is, therefore no doubt that the process of ammonification is an autocatalytic chemical reaction and that the increase in NH_4-N in this process was found to obey the equation

$$\log \frac{x}{a-x} = k\ (t-t_1)$$

From the practical standpoint it may be considered that while the ammonification of compound is still going on in the soil a part of ammonia produced may be converted to nitrites and nitrates. Some of the ammoniacal nitrogen is also lost through denitrification. Therefore the ratio between the nitrogen in the substance added and the nitrogen in the ammonia produced never attains its final value. Consequently the total amount of nitrogen in the substance added may be gradually converted into NH_4-N. But when we consider ammonification from scientific standpoint, it is interesting and important to know whether the total amount of nitrogen added will be ammonified or not. The rate of transformation in this process of ammonification is clearly shown by the equation, because 'a' in the above equation represents the maximum amount of NH_4-N produced. The actual value of 'a' has been found to be always less than the amount of nitrogen added. This means that the nitrogen added is not completely ammonified. The value of "a" for albumin was found to be always greater than blood meal or neem cake which means that these substances are ammonified in the order of albumin > blood meal > neem cake.

The value of 'a' of each substance was also found to be influenced by the type of the soil.

SUMMARY

The ammonification of nitrogen substance was studied in different soils. It was observed that the increase in NH_4-N in the process of ammonification follow the equation

$$\log \frac{x}{a-x} = k\ (t-t_1)$$

The total amount of nitrogen added was not transformed to NH_4-N and the transformation of nitrogen appears to be influenced by the soils and the substance used.

REFERENCES

1. Lemmermann, O.; Fischer, H. & Heinitz, B. 1911. *Landw. Jahrb. Bd.* **41**, 755.
2. Lipman, J. G.; Blair A. W.; Owen, I. L. & Mclean, H. C. 1912. *N. J. Agr. Exp. Sta. Bul.* 247·22.
3. Miyake, K. 1916. *Soil Sci.* **2**, 481.
4. Warington, R. 1879. A report of Experiments made in Rothamsted Laboratory.

STUDIES ON THE EFFECT OF DILUTION, DIALYSIS AND NON-ELECTROLYTES ON THE STABILITY OF CADMIUM FERROCYANIDE SOL

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SUMMARY

The constants *a*, *m* and *n* of the equation $C=a+\frac{m.1/t}{n+1/t}$, proposed by Bhattacharya (1), have been employed to discuss the effect of dilution, dialysis and of non-electrolytes on the stability of cadmium ferrocyanide sol.

INTRODUCTION

Bhattacharya, *et al.*, (1) established the relation between the electrolyte concentration, C and the inverse of the corresponding time of coagulation and obtained hyperbolic curves in the majority of cases, although straight lines were obtained in some cases. The relation established by them is,

$$C=a+\frac{m.1/t}{n+1/t}. \qquad \ldots.(1)$$

where *a*, *m* and *n* are constants. The equation on simplifying assumes the form :

$$1/C-a=(n/m).t+1/m \qquad \ldots.(2)$$

Accordingly, a verification of the equation can be made from the coagulation data if the plots between $1/C-a$ and t provide a straight line.

In this communication, the constants *a*, *m* and *n* have been employed for a comperative study of the influence of dilution, dialysis and of non-electrolytes on the stability of cadmium ferrocyanide sol.

EXPERIMENTAL

The sol was prepared by the method of double decomposition. The amounts of cadmium sulphate and potassium ferrocyanide required to precipitate 2·5 gms of the cadmium ferrocyanide were calculated from the following Stoichiometric equation :

$$CdSO_4+K_4Fe(CN)_6=K_2CdFe(CN)_6+K_2SO_4$$

calculated amounts of the reactants were mixed in the ratio of 1 equivalent of $CdSO_4$: 5/4 equivalents of $K_4Fe(CN)_6$. The sol could only be obtained when $CdSO_4$ solution was gradually added to diluted $K_4Fe(CN)_6$ solution with constant stirring. Dialysis was carried out by keeping distilled water in the outer vessel.

Three different samples of the sol were prepared. One sample was used for the study of the effect of dilution, the second for the effect of dialysis and the third for the study of non-electrolytes effect.

The constants of Bhattacharya's equation were evaluated as follows:

Time of coagulation of the sol was determined by Light Extinction Method (2) using a "Gallenkamp" photoelectric colorimeter. The extinction was plotted against time (Fig. 1) and then a straight line parallel to time axis was drawn as to cut all the curves at different points referring to the same state of aggregation in the different cases.

The inverse of coagulation time thus obtained were plotted against the electrolyte concentration and the value of '*a*' was determined as the concentration extrapolated to $1/t \rightarrow 0$, as shown in Fig. 2. Finally, $1/C - a$ was plotted against t, and straight lines as shown in Fig. 3 were obtained as expected from equation (2). The values of m and n can be obtained from these straight lines (loc. cit.). Figs. 1, 2, 3 represent curves obtained by using KCl as coagulating electrolyte for the sol dialysed for one day. In other studies similar curves were obtained.

OBSERVATIONS

TABLE 1

Effect of dilution

	KCl			$BaCl_2$			$AlCl_3$		
	a (mM/l)	m (mM/l)	n (min.^{-1})	a (mM/l)	m (mM/l)	n (min.^{-1})	a (mM/l)	m (mM/l)	n (min.^{-1})
Sol A	50	200	0·04	0·20	2·00	0·072	0·10	0·416	0·0216
Sol A/2	75	500	0·08	0·10	1·25	0·043	0·07	0·384	0·0455
Sol A/4	100	1000	0·10	0·05	1·00	0·038	0·04	0·312	0·0740

TABLE 2

Effect of dialysis

Electrolyte—KCl

Sol dialysed for (days)	Sp. Cond. × 10^3 (mhos) at 25°C	a (mM/l)	m (mM/l)	n (min.^{-1})
1	1·76	45	58·82	0·0494
2	1·50	40	52·63	0·0473
3	1·17	35	55·55	0·0434
4	1·00	30	58·82	0·0425
5	0·87	25	60·60	0·0358
6	0·80	20	55·55	0·0323

TABLE 3

Effect of non-electrolytes

Electrolyte—KCl

	a (mM/l)	m (mM/l)	n (min.^{-1})
Ethanol (0·5 ml.)	20	21·05	0·046
,, (1·0 ,,)	8	10·53	0·0280
,, (1·5 ,,)	4	6·20	0·0252
Acetone (0·5 ,,)	28	18·20	0·0712
,, (1·0 ,,)	10	12·50	0·0531
,, (1·5 ,,)	4	6·67	0·0333
Dioxane (0·5 ,,)	20	20·00	0·0714
,, (1·0 ,,)	4	13·33	0·0632
,, (1·5 ,,)	1	5·40	0·0414
Glycerol 50% (1·0 ,,)	40	52·63	0·0763
,, ,, (2·0 ,,)	30	50·00	0·0325
Pure Sol	40	52·63	0·0763
Glucose 50% (1·0 ,,)	50	44·45	0·0933
,, ,, (2·0 ,,)	60	55·56	0·300
Urea 50% (1·0 ,,)	55	41·67	0·0833
,, ,, (2·0 ,,)	65	45·00	0·1600

DISCUSSION

Since in all cases of the present studies the plots of $1/C—a$ and t are found to be straight lines (as represented by Fig. 3), it confirms the applicability of the equation (2) and consequently equation (1) for the coagulation of the sol by electrolytes, in the partially dialysed state and also in presence of non-electrolytes.

If $1/t$ is put equal to zero in the above equation (1), we obtain $C=a$. It follows that '*a*' is the concentration of the electrolyte which will coagulate the sol in infinite time. In other words, we may say that the sol can remain stable upto a concentration given by '*a*' and hence '*a*' has been designated as the critical stability concentration of the electrolyte for the sol.

It is evident from table 1 that the critical stability concentration '*a*' of the electrolyte decreases with the valency of the precipitating ion which is in agreement with Schulze—Hardy law.

If $1/t$ is made large, as compared to n, the equation $C=a+\frac{m.1/t}{n+1/t}$ takes up the form :

$C=a+m$. This means that m is the excess of the electrolyte that should be added above the critical stability concentration in order to cause immediate coagulation of the sol. It may be said that at $C=a+m$, the region of slow coagulation merges into that of rapid coagulation. Table 1 shows that the value of $(a+m)$ increases for monovalent ions with dilution of the sol but decreases for di- and tri-valent ions. From this it may be inferred that the stability towards monovalent ions of a highly purified cadmium ferrocyanide sol increases with dilution, but towards di- and tri-valent ions the sol becomes less stable.

The decrease in the value of 'a' shows that the value of concentration causing no coagulation is reached at a lower concentration on dialysing the sol (table 2). The decrease in the values of m indicates that a much smaller quantity of the electrolyte is required on dialysing the sol to cause its instantaneous coagulation. Similarly the decrease in the value of n indicates a greater degree of aggregation on dialysis.

A sol is well known to become increasingly sensitive with progressive dialysis and since a, m and n are connected with the sensitivity, the values of these constants should decrease with the time of dialysis and this fact has also been confirmed experimentally.

The values of the constants a, $(a+m)$ and n show a decrease in the presence of ethanol, acetone, dioxane and glycerol but the presence of glucose and urea causes an increase. From this it may by inferred that ethanol, acetone, dioxane and glycerol sensitise the sol against KCl as in the presence of these non-ionic substances the region of slow coagulation merges into that of rapid coagulation earlier as evidenced by the low values of $(a+m)$. Glucose and urea stabilise the sol. The extent of stabilisation or sensitisation increases with the increased non-ionic additions.

Thanks are due to Dr. A. K. Bhattacharya, D.Sc., F.R.I.C., Prof. of Chemistry, University of Jammu and Kashmir and Dr. A. Kumar for their valuable suggestions in this work.

REFERENCES

1. Bhattacharya, A.K. et al., *J. Ind. Chem. Soc.*, **28** : 179 & 638 (1951); **29** : 687 & 759 (1952); *J. Colloid. Sci.* **10** : 551 (1955); **11** : 124 (1956); *Agra Univ. J. Res. Sci.)*, **12** : 101 (1963).
2. Colloid Science Vol. I. 1952. Edited by H.R. Kruyt, page 296.

Coagulation of Cadmium Ferrocyanide Sol. with KCe

Fig. 1. Extinction vs Time Curves

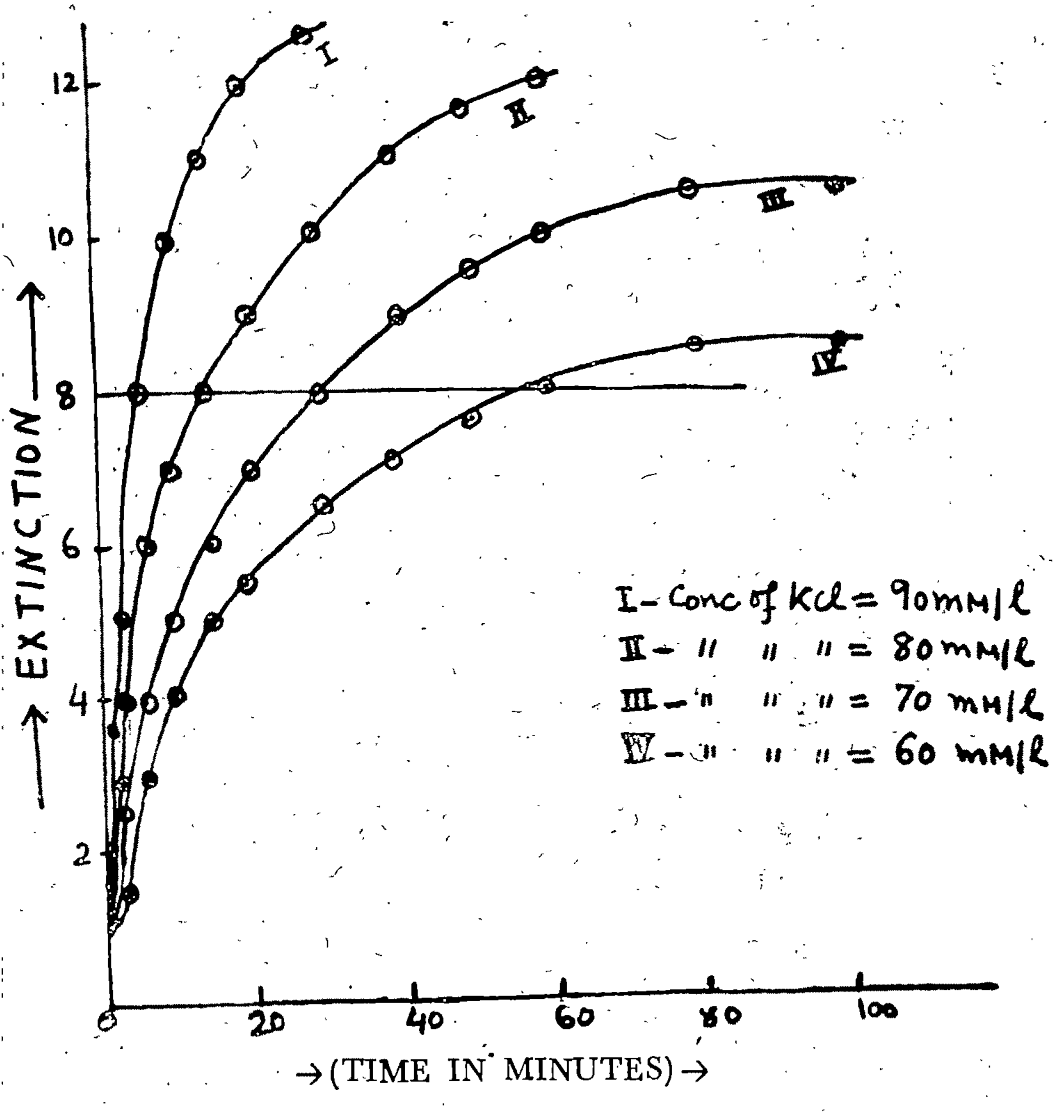


Fig. 2 C vs 1/t

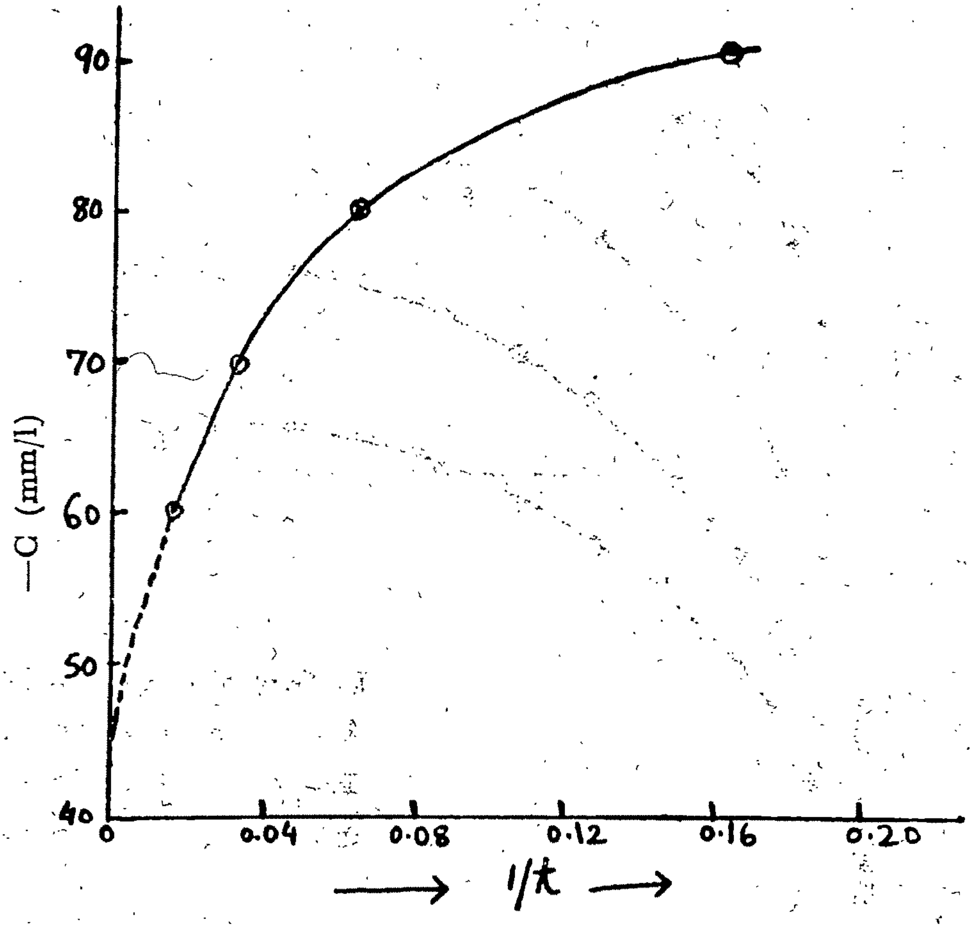
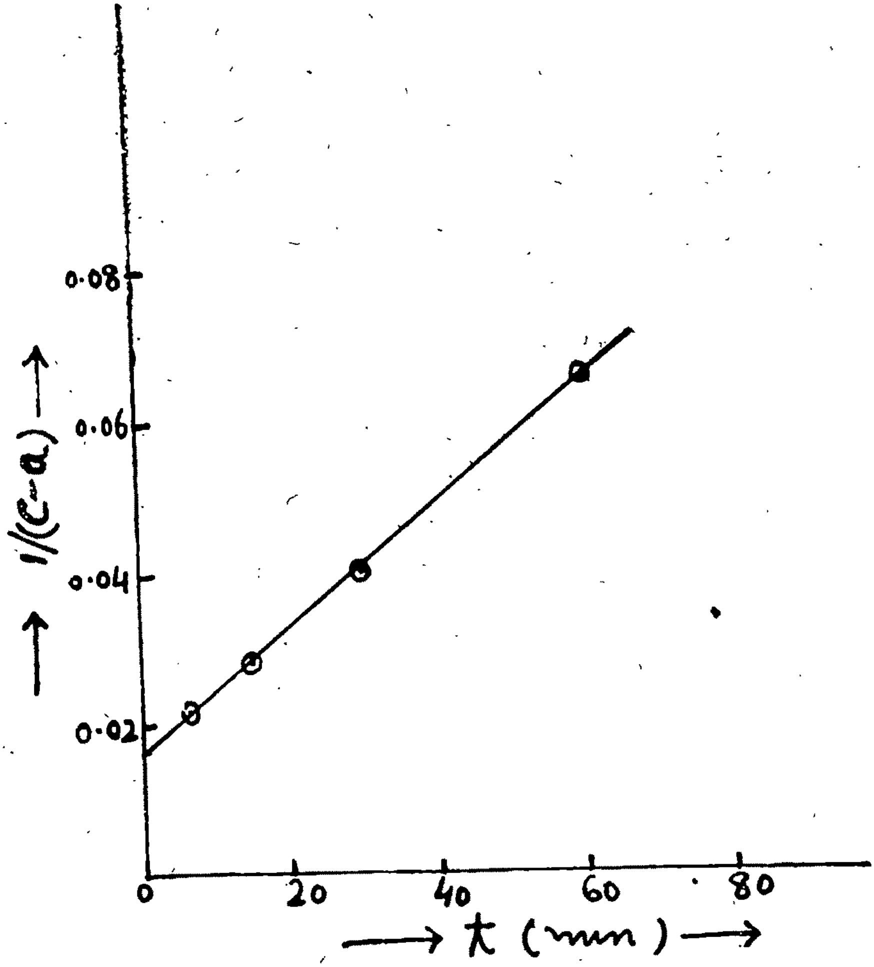


Fig. 3. 1/ (C—a) vs t



STABILITY OF PLASMA IN AN AXIALLY SYMMETRIC MAGNETIC FIELD

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INTRODUCTION

An attempt has been made to analyse the equilibrium of a cylindrical plasma column of infinite length along Z-axis in the presence of a uniform magnetic field along the same. The lines of force are supposed to be on the surface of coaxial cylinders so that the Z-axis also serves as the axis of symmetry. It is concluded that a uniform field along the Z axis stabilises the plasma while on azimuthal field on the other hand makes the plasma unstable.

In this method approach is similar to that of a Talwar [3] who considered the Rayleigh instability of an incompressible, inviscid, perfectly conducting plasma, for a two dimensional perturbation of the type e^{ikx+nt}, where the field was assumed to be in the direction of the x-axis. A few special cases of the problem were also considered by him.

THE EQUATIONS OF THE PROBLEM

We assume the cylindrical column to extend to infinity along the Z-axis with external gravity acting along r with $\phi=0$. We employ cylindrical coordinates (r, ϕ, z) and assume the radius to be arbitrary. The plasma is supposed to be infinitely conducting, inviscid, and incompressible and the small perturbation to which it is subjected is supposed to correspond to an irrotational velocity field $(\vec{V})$ having a scalar potential ψ. The magnetic field is supposed to fulfil the following conditions [1].

$$D_2(\vec{H}) \equiv \frac{\partial}{\partial \phi}(\vec{H})=0, \quad D_3\,(\vec{H}) \equiv \frac{\partial}{\partial z}(\vec{H})=0, \quad D_1\,(H) \equiv \frac{\partial(H)}{\partial r} \neq 0 \tag{1}$$

Also, for no variation along the r direction, H_γ being zero satisfies the condition.

$$\text{Div } \vec{H}=0 \tag{2}$$

In the case of an inviscid, incompressible and infinitely conducting fluid the equation of motion is

$$\rho \frac{\partial \vec{V}}{\partial t} + \rho\,(\vec{V}.\nabla)\,\vec{V} = -\nabla p + \rho \vec{g} + \frac{\mu}{4\pi}\,(\text{curl } \vec{H} \times \vec{H}) \tag{3}$$

where $\vec{V}$ is the velocity, $\vec{H}$ the magnetic field, ρ the density of the fluid and p the pressure. Magnetic permeability μ is taken to be unity. The equation of continuity for an incompressible fluid is

$$\text{Div}\ \vec{V}=0 \qquad ..(4)$$

and also

$$\frac{\partial \rho}{\partial t}+(\vec{V}.\ \nabla)\ \rho=0 \qquad ..(5)$$

For an infinitely conducting medium,

$$\frac{\partial \vec{H}}{\partial t}=\text{curl}\ (\vec{V}\times\vec{H}) \qquad ..(6)$$

which on using (2) becomes

$$\frac{\partial \vec{H}}{\partial t}+(\vec{V}.\ \nabla)\ \vec{H}=(\vec{H}.\ \nabla)\ \vec{V} \qquad ..(7)$$

Equations of Perturbations

We now investigate the stability of magnetohydrostatic equilibrium ($\vec{V}=0$) by giving a small perturbation of the type exp $(ikz+im\phi+nt)$ in the r, ϕ, z plane. We assume that the components V_r, V_ϕ, V_z, of the perturbation velocity field exist and that for these and other perturbed quantities the following operations are valid:

$$D_3\equiv\frac{\partial}{\partial z}=ik,\quad \frac{\partial}{\partial \phi}=D_2=0,\quad \frac{\partial}{\partial t}=n \qquad ..(8)$$

Further, suppose that the perturbation velocity field is irrotational and possesses a scalar potential ψ so that

$$V=-\text{grad}\ \phi\ (r,\ \phi,\ z,\ t) \qquad ..(9)$$

then with (4) we have

$$\nabla^2\ \psi=0 \qquad ..(10)$$

This equation can be solved by the method of separation of variables which yields [3]

$$\psi=[A\ J_m\ (kr)+B\ Y_m\ (kr)]\ exp\ (ikz+im\phi+nt) \qquad ..(11)$$

where J_m (kr) and Y_m (kr) are Pessel functions for integer order $m=0$, 1, 2 and A and B are constants. As $r\to0$, Y_m $(kr)\to\infty$. Here, for small perturbations right upto the axis of symmetry one requires that B should vanish. Besides, as $\frac{\partial V}{\partial \phi}=0$ from equation (5) we need $m=0$. This makes $V_\phi=0$ and which as we shall see further can be possible only if H_ϕ or H_z be absent. So finally we have

$$\psi=A\ J_0\ (kr)\ exp\ (ikz+nt)=J_0\ (kr)\ F \qquad ..(12)$$

The meaning of F is obvious. Thus k is the wavenumber $\frac{2\pi}{\lambda}$ for the perturbation and 'n' determines the rate at which the perturbation develops in time.

From equation (8) we conclude

$$V\phi=0 \qquad ..(13)$$

$$V_z=-ik\ J_0\ (kr).\ F\equiv-\frac{\partial\psi}{\partial z} \qquad ..(14)$$

$$Vr=k\ J_1\ (kr)\ F\equiv-\frac{\partial\psi}{\partial r} \qquad ..(15)$$

$$D_1\ (Vr)\equiv\frac{\partial Vr}{\partial r}=\frac{k^2}{2}\ [J_0\ (kr)-J_2\ (kr)]\ F \qquad ..(16)$$

$$D_1^2\ (Vr)\equiv\frac{\partial^2 .Vr}{\partial r^2}=\frac{k^3}{4}\ [-3\ J_1\ (kr)+J_3\ (kr)] \qquad ..(17)$$

Here $J_0\ (kr)$, $J_1\ (kr)$, $J_2\ (kr)$ and $J_3\ (kr)$ are Bessel functions, which for the sake of abreviation will be written as J_0, J_1 and J_2 etc. The perturbation velocity field specified above will affect pressure, density and magnetic field. We will denote by (δp), $(\delta\rho)$ and '*h*' the corresponding perturbations. The perturbed equation of motion is

$$\rho_0\, n\vec{V}=-\nabla\ (\delta p)+g(\delta\rho)+\frac{1}{4\pi}[(\text{curl}\ \vec{H}\times\vec{h})+(\text{curl}\ \vec{H}\times\vec{h})] \qquad ..(18)$$

Equations (2) and (4) give

$$\text{Div}\ \vec{h}=\frac{hr}{r}+D_1\ (hr)+ikh_z=0 \qquad (19)$$

$$\text{Div}\ \vec{V}=\frac{1}{r}\frac{\partial}{\partial r}\ (r\ V_r)+ik\ V_z=0 \qquad (20)$$

$$\text{or}\quad V_z=\frac{i}{k}\left[D_1\ (V_r)+\frac{V_r}{r}\right]$$

where $D_1=\frac{\partial}{\partial r}$. We find that our assumed velocity field (9) satisfies the equation (20). From equation (7) we have

$$\frac{\partial\vec{h}}{\partial t}+(\vec{V}.\ \nabla)\ \vec{H}=(\vec{H}.\ \nabla)\ \vec{V} \qquad (21)$$

For all perturbed quantities equation (8) is assumed. The equation of motion written in terms of components gives

$$4\pi n^2\ \rho_0\ Vr=-4\pi n\ D_1\ (\delta p)+4\pi ng\cos\phi\ (\delta\rho)_r+ + \left[ikH_z\ nh_r-\frac{2H\phi\ nh\phi}{r}-D_1\ (nh\phi\ H\phi+nh_z\ H_z)\right] \qquad ..(22)$$

$$4\pi n^2\ \rho_0\ V\phi=0=-4\pi ng\ \sin\phi\ (\delta p)\phi+\left[nh_r\left\{\frac{H\phi}{r}+D_1\ (H\phi)\right\}+ +ikH_z\ nh\phi\right] \qquad ..(23)$$

$$\text{and}\ \ 4\pi n^2\ \rho_0\ V_z=-4\pi nik\ (\delta p)+[-ikn\ H\phi\ h\phi+nh_r\ D_1\ (H_z)] \qquad ..(24)$$

From (21), we have for hr, $h\phi$ and hz

$$nh_r = ik\, H_z\, V_r \qquad ..(25)$$

$$nh_\phi = -V_r\, D_1\, (H\phi) \qquad ..(26)$$

$$nh_z = ik\, H_z\, V_z - V_r\, D_1\, (H_z) \qquad ..(27)$$

$$= -H_z \left[\frac{V_r}{r} + D_1\,(V_r)\right] - V_r\, D_1\,(H_z)$$

Equation (5) gives us

$$\frac{\partial}{\partial t}\,(\delta\rho) + (V.\ \nabla)\rho_0 = 0 \qquad ..(28)$$

where ρ_0 is the unperturbed density. Obviously we have

$$n\,(\delta\rho) + V_r\, D_1\,(\rho_0) = 0$$

$$(\delta\rho)_r = -V_r\, D_1\,(\rho_0)/n \qquad ...(29)$$

Since no $(\delta\rho)_\phi$ and $(\delta p)_z$ are assumed to exist, the first term on right hand side of (23) vanishes. Now, substitution of hr and $h\phi$ from (25) and (26) in (23) gives a condition under which assumption $\frac{\partial V}{\partial \phi} = 0$ or $V\phi = 0$ is valid we get

$$H\phi\, H_z = 0 \qquad ..(30)$$

Thus either $H\phi$ or H_z become zero in the final equation. We shall make this change only at the end. Incidentally, components hr and hz satisfy equation (19). After eliminating (δp) from equations (22) and (24) for which we multiply (22) by ik and operate with D_1 on (24), we get after substituting nhr, $nh\phi$, nhz from (25), (20) (27)

$$\left[\frac{4\pi\, n^2\, \rho_0}{k^2} + H_z^2\right] D_1^2\,(V_r) + \left[\frac{4\pi n^2\, D_1\,(\rho_0)}{k^2} + \frac{4\pi n^2\, \rho_0}{k^2 r} + \frac{H_z^2}{r} + \right.$$

$$\left. + 2H_z\, D_1\,(H_z)\right] D_1\,(V_r) + \left[\frac{4\pi n^2\, D_1\,(\rho_0)}{k^2 r} - \frac{4\pi n^2\, \rho_0}{k^2\, r^2} - 4\pi n^2\, \rho_0 - 4\pi\, ges\phi\, D_1\,(\rho_0)\right.$$

$$\left. + \frac{2H\phi\, D_1\,(H\phi)}{r} + \frac{2H_z\, D_1\,(H_z)}{r} - k^2\, H_z^2 - \frac{H_z^2}{r^2}\right] Vr = 0 \qquad ..(31)$$

In deriving this equation we have used (29) and also

$$D_1\,(\rho_0\, V_z) = \rho_0\, D_1\,(V_z) + V_z\, D_1\,(\rho_0)$$

$$= \frac{ik}{k^2}\left[\rho_0\, D_1^2\,(V_r) + \left\{D_1\,(\rho_0) + \frac{\rho_0}{r}\right\} D_1\,(V_r) + \left(\frac{D_1\,(\rho_0)}{r} - \frac{\rho_0}{r^2}\right) V_r\right] \qquad ..(32)$$

where equation (20) has been used to obtain V_z and $D_1\,(V_z)$

Case I

We assume the following

$$D_1\,(\rho_0) = 0,\ H\phi = 0,\ H_z = H_0,\ D_1\,(H_z) = 0$$

Under these conditions assumption $\frac{\partial}{\partial \phi}$ vanishes [CF, eqn. (28)] vanishes. Using equation (16) and simplifying we have

$$\frac{1}{r}\left[\frac{4\pi n^2\rho_0}{k^2}+H_0^2\right]\left[\frac{k^3r}{4}(-3\,J_1+J_3)+\frac{k^2}{2}(J_0-J_2)\right]F-k\,J_1$$

$$\left[\frac{4\pi n^2\rho_0}{k^2r^2}+4\pi n^2\rho_0+k^2H_0^2+\frac{H_0^2}{r^2}\right]F=0 \qquad ..(33)$$

Remembering that

$$k^2r^2\,(J_1+J_3)+2kr\,(J_0-J_2)=4\,J_1 \qquad ..(34)$$

we finally have

$$n^2=-\frac{k^2H_0^2}{4\pi\rho_0} \qquad ..(35)$$

Obviously, n is imaginary, so far any 'k' and any 'r' oscillations will develop but they will remain small in amplitude, so the system is stable for such perturbations. If the cylindrical plasma column is surrounded by a rigid boundary at $r=R$, the boundary conditions make V_r vanish at the boundary.

Now we can write

$$V_r=A(\alpha\,e^{pt}+\beta\,e^{-pt})\,J_1\,(kr) \qquad ..(36)$$

at the boundary, $r=R$, so

$$V_r=A\,(\alpha\,e^{pt}+\beta e^{-pt})\,J_1\,(kr)=0 \qquad ..(37)$$

This, for the moment $t=0$ (as boundary conditions have to be satisfied for all moments) gives

$$A\,(\alpha+\beta)\,J_1\,(kr)=0$$

So the condition is satisfied if each of the quantities $A\,(\alpha+\beta)\,J_1\,(kr)$ separately vanish.

If $A=0$ [Cf equation (12)] we have $\psi=0$. *i.e.* no perturbation is applied at all. On the other hand, if $J_1\,(kR)=0$, we cannot satisfy the boundary condition $V_r=0$ at $r=R$ for arbitrary so if in the small perturbation all wave numbers be present then to satisfy the condition $V_r=0$ at $r=R$, for arbitrary wave number, we need $\alpha=-\beta$

Case II

$$D_1\,(\rho_0)=0,\ H_z=0,\ D_1\,(H_\phi)\neq 0$$

Now at $r=0$, on the axis of the cylinder, H_ϕ does not exist so we assume

$$H_\phi=H_0\left(\frac{r}{R}\right)^\theta \qquad .\ (38)$$

where θ is an integer is greater than zero

$$D_1\,(H_\phi)=\frac{H_0\,\theta r^{\theta-1}}{R^\theta}$$

and

$$H_\phi D_1\,(H_\phi)=H_0^2\theta\,r^{2\theta-1}\mid R^{2\theta} \qquad (40)$$

In this case after simplification we get from equation (31) and (18)

$$4\pi n^2 \rho_0 [k^2 r^2 (-3J_1+J_3)+2kr (J_0-J_2)] + 4[4\pi n^2 \rho_0 - 2k^2 r H_\phi D_1 (H_\phi)] J_1 = 0 \quad ..(41)$$

using again equation (32) we get

$$n^2 = \frac{H\phi D_1 (H\phi)}{4\pi \rho_0 r} \quad ..(42)$$

substituting the values of H_ϕ and $D_1 (H_\phi)$ from equations (33) and (42) we get

$$n^2 = \frac{H_0^2 \theta r^{2\theta-2}}{4\pi \rho_0 R^{2\theta}}$$

obviously in this case, the plasma is unstable for the specified type of field.

We note further, that n, a quantity which determines the rate at which the perturbation develops in time, depends on r, the space variable. This is in accordance with the Lorentz force $F = \frac{e}{c} (\vec{V} \times \vec{H})$. If θ is greater than unity the frequency of perturbation grows in space also. For $\theta=1$, *i.e.* when the field (h) varies linearly with r, we have

$$n^2 = \frac{H_0^2}{4\pi \rho_0 R^2}$$

This means that our assumption of being an explicit function of time only corresponds to case $\theta=1$. For more complicated geometry of the field we should take into account the variation of n with r.

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REFERENCES

1. Pikelner, S. B. & Gershberg, R. Y. 1959. *Astronom. Zhur* **36,** 785.
2. Relton, F. E. 1946. Applied Bessal Functions, p. 133, (Blackie and Son Limited).
3. Talwar, S. P. 1959. *Zeit F. Ap.* **47** : 161.

ROLE OF IMPURITIES IN URANYL SALTS

[PART II—URANYL ACETATE]

D.N. PANDE AND D.D. PANT

INTRODUCTION

Uranyl acetate dihydrate has been studied by a number of earlier workers. The bands had been tabulated by Nichols and Howes[1] and the same spectrum was reported by Pant[2], Freymann[3] and others.[4-8] Unlike the cases in chloride[9], there appeared no confusion regarding the dependence of the spectrum upon the samples investigated. The anhydrous sample, which is known, gives an entirely different spectrum and no bands in it appear common with that of the dihydrate. In solutions uranyl acetate has been reported to undergo very complicated changes in its fluorescence spectrum.[10,11] In the following the changes in solid state are reported which will corroborate the results arrived in the previous paper.

EXPERIMENTAL

The various samples were obtained from the commercial uranyl acetate dihydrate (from B.D.H., A.R. Grade) by recrystallising from aqueous and acidic solutions under the various conditions described later below. The original salt when exposed to moist atmosphere changes its colour from greenish-yellow to orange-red. Some samples were studied during this change.

The spectra have been studied in the 1·5 metre grating and also in Hilger large prism spectrograph. There was no difficulty in obtaining the fluorescence spectra, but the absorption could not be studied in details except in few cases due to the scattering losses in most of the powder samples. The temperature variation of fluorescence intensity has been studied with the monochromator and photo multiplier arrangement as usual.

RESULTS

A. Depending upon the conditions of preparation, at least five forms of uranyl acetate are obtained giving different spectra. The nomenclature and some brief information about them is collected in table 1.

TABLE 1

Sample	Method of preparation	Nature of fluorescence spectrum at—185°C
S_1	Original salt and recrystallisation from 25% acid solutions	Spectra nearly the same as of the original dihydrate
S_2	Crystallisation from dilute acqueous solution on slow evaporation	Spectrum shifted to the red of S_1 by Ca 300 cm^{-1}
S_3 & S_4	Precipitation on boiling Conc. aqueous solution or prolong exposure to atmospheric moisture	The spectrum corresponding to S_3 is shifted by ca. 1400 cm^{-1} and that of S_4 by ca 2500 cm^{-1} to the red of S_1
S_5	Crystallisation from highly acidic (75% acid) conc. solution	Spectrum shifted to the violet of S_1 by Ca. 100 cm^{-1}

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B. The fluorescence spectrum of the commercial dihydrate at 85°C is shown in Fig. 1-a. The salt on recrystallisation from 25% acid solution gives slightly larger bright-green crystals and the spectrum is not changed to any extent (Fig. 4-b). The most intense bands belong to the B series, which is common in fluorescence and absorption. The C series is the next strongest and E series is weakly present. Both these series show multiplet structures. The wave numbers of the bands are given in table 1-a and agree entirely with the earlier data. It is, however, noted that one series of weak and diffuse bands (L′) just to the red of the E series at Ca 310 cm^{-1} from B series appears with slightly varying intensity in different recrystallised samples and in some cases the B bands are accompanied by diffuse background. The B_0 line is accompanied by some weak red companions at ca.15 to 30cm^{-1}. In higher groups the C series has a weaker red companion which can be attributed to some another weak series of which the first member L_0 is present in the first group also ($B_0-L_0=82cm^{-1}$). The ν_1 and ν_3 frequencies in the ground state are 860 and 946 cm^{-1} respectively and the ν_2 frequency is tentatively assigned the value 259 cm^{-1}. These samples of acetate will be here after called S_1.

C. Slow evaporation of aqueous solutions of acetate S_1 sometimes gives a greyish-white product consisting of fine particles. The mother liquor was decanted and the precipitate washed and dried over filter paper. This sample is weakly fluorescent at room temperature. The fluorescence spectrum at −185°C is given in Fig. 1-b. It appears to be the first hydrolysed product* of uranyl acetate and hereafter will be called S_2 as in chloride (previous paper). The fluorescence bands are, however, quite sharp and are given in table 2-a. It will be seen that the resonance band, which is a close doublet ($\triangle\nu=14$ cm^{-1}), is shifted by Ca. 310 cm^{-1} to the red with respect to the B_0 of S_1 and coincides with the weak band L'_0 of the latter. It is, however, interesting to note that in higher groups the bands of this series (B) in the spectrum of S_2 are shifted progressively by small amounts to the violet with respect to the L′ band of S_1 (Fig. 4).

The other series of bands in the fluorescence of S_2 are very weak (Figs. 1-b and 6-b), but the ν_3 and ν_2 frequencies do appear albeit weakly. The ν_1 (850 cm^{-1}) and ($\nu_3$939 cm^{-1}) in case of S_2 are smaller than the corresponding frequencies in S_1 ($\nu_1=860$; $\nu_3=946$ cm^{-1}), but the change is not as conspicuous as in case of chloride. The ν_2 frequency, 257cm^{-1} in S_2, is not changed so markedly with respect to that in S_1 (259cm^{-1}). Again comparison of the spectra of chloride S_1 and $Cs_2UO_2Cl_4$ also shows that the bending vibrational frequency is not changed to the same extent as the ν_1 or ν_3 frequency. This rather helps in supporting the assignment of 259 cm^{-1} to ν_2 in case of S_1 which at first was only tentative.

D. When acetate S_1 is exposed to moist atmosphere it gradually changes into a orange-red powder. The spectral changes in fluorescence at R.T., recorded with the photomultiplier arrangement, are shown in Fig. 3. It will be seen that with the time of exposure to the atmosphere the bands in the higher groups become very diffuse and the intensity successively shifts to the red. The fluorescence spectra of such mixed samples, corresponding to Fig. 3, at —185°C are shown in Fig. 1c and 4 d. It may be seen that there are the sharp bands of S_1 and S_2 in the first and second groups and after second group a new set of bands, resembling the δ bands of the higher hydrolysed species of Pant and Khandelwal, starts at ca $1400 cm^{-1}$ to the red of the B_0 of S_1 (Fig. 4d). These extra bands are quite similar to the B′, C′ bands of chloride S_3 in regard to there relative position and the frequency interval ν_1 ($825 cm^{-1}$) with respect to that of acetate S_1. The substance giving rise to these bands is, therefore, the second hydrolysed product of acetate and will be called S_3, but it has not been completely isolated. Still further to the red some very diffuse bands appear near the B series of S_1 after the 3rd group and infact the B bands of S_1 are very much marked by them. These diffuse bands appear to belong to the orange coloured substance mentioned above which is a still higher hydrolysed species of acetate and will be called S_4. It appears that S_3 is perhaps unstable and changes rapidly into S_4. The fluorescence spectrum at —185°C of a sample consisting mainly of S_4 is given in Fig. 1-d. The positions of the bands belonging to S_3 are given in table 3-a. The ν_1 (825) and ν_3 (913) frequencies are appreciably lower than in case of S_1 and S_2. It appears that the ν_2 frequency is also present but the bands corresponding to this (E series) are masked by the diffuse bands of S_4 (Fig. 4-d). The positions of the peaks in the spectrum of S_4 as given in table 4-a and it appears that the frequency (ν_1) is not changed much in going from S_3 to S_4.

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* Though the bands are rather sharp for a hydrolysed sample, the remarkable increase in intensity on cooling supports our view.

The change from S_1 to S_4 is very rapidly effected by boiling a concentrated aqueous solution of acetate dihydrate repeatedly. The orange coloured substance, perhaps together with some other species (S_2 and S_3), begins to precipitate after some time. The mother liquor can be decanted and the precipitate can be washed repeatedly giving ultimately S_4. The two samples obtained by exposure to moist atmosphere and by boiling the aqueous solution of S_1 are identical. This leaves no doubt that the action of atmospheric moisture is also to promote hydrolysis and the changes shown in Fig. 3 are due to the presence of S_2, S_3 and S_4 in S_1 in the intermediate stages.

E. The intensity variation of fluorescence with temperature is shown in Fig. 6 a-c, for S_1, S_2 and S_4 respectively. It will be seen that the intensity falls more rapidly with rise in temperature in case of S_2 and S_4 relative to that of the normal salt S_1. This behaviour of the hydrolysed product is similar in chloride and acetate.* It may be noted that the main bands in Figs. 1-d and 6-c have some shoulders to the violet side. These are most probably due to the presence of S_3 and S_4 as impurity. These components also behave in a similar manner as the bands of S_4.

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* The γ^* etc. bands of solution, which belong to hydrolysed species, behave similarly.

F. The absorption spectrum of S_1 consists of at least four electronic transitions as in other salts[13]. The fluorescence series consists of a single strong line in the first group (b_0) and can be followed upto the fourth group. The two lines in the second group of fluorescence series are at 698 and 731cm^{-1} from b_0 and are probably due to the ν'_1 and ν'_3 of the UO_2 group. Both the frequencies are repeated in higher groups, but the bands corresponding to ν_1', $2\nu_1'$ etc. are very weak. At the longer wave length side of the second group of fluorescence series the magnetic series starts at about 653 cm^{-1} above the b_0 band. The magnetic series* can also be followed upto the 3rd group and is slightly weaker than the fluorescence series. The frequency interval in this series is 695cm^{-1} which is quite close to the ν'_1 frequency in the fluorescence series. The diffuse series starts in between the 3rd and 4th groups of the fluorescence series with a relatively strong and diffuse band at about 1843 cm^{-1} above the b_0. From this region onward the absorption is mainly due to diffuse series which in higher groups is a doublet ($\triangle\nu$=200 cm^{-1}). The vibrational frequency in the series is Ca. 720 cm^{-1}. After sixth group of diffuse series, the ultra violet series starts at Ca. 6060 cm^{-1} above the fluorescence series. The bands of the ultraviolet series are weak and sharp with a interval of 730 cm^{-1}. All these series are marked in Fig. 2-a, and the wave numbers of the bands are given in table 2-a.

G. In the absorption of S_2 (Fig. 2-b) there are two bands in the first group. The longer wavelength band (which is a close doublet, $\triangle\nu$=14cm^{-1}) is the resonance band of S_2. The shorter wavelength band is generally very weak but appears with variable intensity in different samples. It coincides with the b_0 band of S_1 which probably appears as impurity in the samples of S_2. The higher members of the impurity bands as before are shifted to the red with respect of the bands of pure S_1 (Fig. 5). It appears tempting to generalise the behaviours of impurities in fluorescence and absorption in view of what has been said earlier regarding S_2 as impurity in S_1. (i) If the impurity has an absorption band at longer wave length than that of the bulk material it appears in fluorescence although its quantity is so small that it does not appear in absorption. (iii) If the impurity has the absorption band on the shorter wave length side it appears in absorption but not in fluorescence†. These observations appear to be generally true for many uranyl salts and as discussed in the previous paper can be attributed to energy transfer processes. (iii) However, another type of observation which has come to light by the studies in the acetate is that, although the (0, 0) band of the impurity does not shift appreciably, the vibrational frequency of the impurity both in the ground and excited states increases or decreases depending upon whether the vibrational frequency of the bulk material is higher or lower than that of the isolated impurity. The impurities obviously do not appear to be as heterogeneous mixture even though most of the samples are in the powder forms. Only S_1 can be obtained as single crystals and when it converts into hydrolysed species it begins to break into a powder. The impurities appear to be formed in the crystal or crystallites during the various chemical changes, e.g., exposure to moist air, precipitation from solutions etc.

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* From the polarization data of Rao and Narsimham the magnetic series is strongly polarized and can thus be identified.

† In a sample of S_2 in which the b_0 band of S_1 was as intense as that of S_2 no fluorescence bands corresponding to S_1 were observed.

The magnetic series in S_2 is weak and diffuse and not much shifted with respect to that in S_1. The second member of the fluorescence series of S_1 is very close to the origin of the magnetic series of S_2. Similarly the diffuse series is also nearly at the same position as in S_1. The frequency intervals between the main absorption bands of S_2 are again smaller than those in S_1 by Ca. 10 cm^{-1}. The measurements of the bands are given in table 2-b. The absorption has not been studied beyond few group of the diffuse series.

The absorption corresponding to S_3 and S_4 could not be studied as the bands are very diffuse and almost continuous heavy absorption starts immediately close to the fluorescence. This feature is common to all higher hydrolysed species of uranyl salts.

H. When S_1 is dissolved in excess of acetic acid (Ca. 75% by volume) the saturated solution (at higher temperatures) quickly crystallises on cooling down to room temperature. The crystals are granular without any regular structure. These crystals can be separated and dried by pressing between filter paper. The fluorescence and part of the absorption spectra of this form of acetate are given in Figs. 1-e and 2-c respectively. The spectra of this form (called hereafter S_5) are altogether different from those of S_1. The resonance band of S_5 lies about 100 cm^{-1} to the violet of the Bo of S_1 (Fig. 4). In fluorescence there are some weak bands at 112 cm^{-1} from B_0 towards the red and in higher groups the C series lies at about the same interval from B series. The C series is stronger than the B series in contrast to other acetate spectra. There is another strong series at 180 cm^{-1} from B series of which the first member is present with nearly the same intensity as B_0. The E series which is at 265 cm^{-1} from B_0 is quite strong and appears as close doublet ($\Delta\nu = 16$ cm^{-1}). There are three sharp lines at Ca. 620 cm^{-1} from the B series. They appear in place of the A series and can be interpreted as transitions from a close level above the first excited state at about 240 cm^{-1} from B_0. In fact a band at this interval has been observed in absorption which is even stronger than the resonance band (Fig. 2-c). The interpretation of the above type of bands in acetates in terms of the acetate group frequency, as suggested by Dieke and Duncan,[13] appears doubtful. The fluorescence spectrum of S_5 very closely resembles in general structure to that of $NaUO_2$ $(CH_3COO)_3$ yet the frequencies are different. It appears that the new species formed in S_5 is of chemical formula UO_2 $(CH_3$ $COO)_3$ like that in sodium uranyl acetate. In other words it is a complex of the uranyl with the anions. The positions of the fluorescence bands and their possible interpretations in terms of uranyl and lattice frequencies are given in table 5-a.

It is found that the crystals of S_5 when exposed to open atmosphere rapidly change into the powder giving mainly the bands of S_1. There can be various intermediate stages in which S_1 is as impurity in S_5 and vice versa. Therefore sometimes a few bands are common in the fluorescence spectra of S_5 and S_1 and appear with variable intensity in the samples of S_5. The B series of S_1 nearly lies at the positions of the C bands of S_5 (Fig. 4). As expected the b_0 band of S_1 has not been observed in the absorption of such samples, though in fluorescence it may appear even stronger than the B_0 of S_5. It may be concluded that the strong fluorescence corresponding to S_1 is excited by some energy transfer processes. There is no change in the frequency interval of the S_1 as impurity compared to that of pure S_1 possibly because the vibrational frequencies of the host crystal are equal to those of the impurity.

The existence of certain phases of the uranyl salts such as acetate S_5 is very transient. Such phases can be quite stable at low temperatures but at higher temperatures (e. g., R. T.) in absence of excess of anions they quickly convert into the more stable forms. Such transient phenomena have also been observed by other workers in this laboratory in the quickly frozen melts of uranyl nitrate hexa-hydrate. Sometimes the frozen mass gives new bands very prominently in addition to those of the normal salt and on raising the temperature the extra bands disappear and do not appear on recooling the same sample. The defects produced on snap freezing at L. A. T. thus get anealed at R. T. or even below.

The absorption spectrum of S_5 (Fig. 2-c) consists of four lines in the first group. The b_0 line and the two other violet members are weak and the fourth band which is at 244 cm^{-1} from b_0 is relatively strong and can be designated a_0. The 244 cm^{-1} frequency is possibly due to the bending of uranyl ion in the excited state. The second group of fluorescence series consists of two close lines in the b band at 705 and 731 cm^{-1} respectively from b_0. These two frequencies are ν'_1 and ν'_3 of the UO_2 group and are quite close to the corresponding values in S_1, only the former is slightly larger than the ν'_1 in S_1, (698 cm^{-1}). The magnetic series starts from the violet side of the 2nd group of fluorescence series as a relatively strong and diffuse doublet at Ca. 910 and 1100 cm^{-1} above b_0. The diffuse series starts from the voilet end of the 3rd group of the magnetic series and has been observed upto the fifth group. These parts of the spectrum are not studied in further details. The positions of the bands upto the 2nd group of magnetic series are given in table 5-d.

I. The spectra of uranyl solutions have been closely studied by others in this laboratory at room and 80°K. The main features are: (1) With increase of pH hydrolysed species are formed. With successive hydrolysis the fluorescence spectrum shifts continuously towards the red and the vibrational frequency of the UO_2 group decreases. The absorption in the diffuse series increases relative to the magnetic and fluorescence series and so does the fluorescence series. (2) In acidic solutions the spectrum shifts slightly to the voilet and the vibrational frequency of the UO_2 group remains constant or slightly increases relative to that of the UO_2^{++} ion in acqueous solution. The magnetic series gains in relative intensity over the diffuse series. The fluorescence series does not gain in intensity. (3) The fluorescence of the frozen uranyl acetate solutions was particularly studied by Pant and Khandelwal, who investigated the effect of varying pH upon the spectra. Their results are in agreement with the above account of the present investigation. Our studies in which solid state reactions are involved compare favourably with the theory of hydrolysis and complex formation with the anions. In the following table we give the relavent information regarding the various samples studied by us in comparison with those found in solutions.

TABLE 2

Solid	Samples	Position of 0,00 band cm^{-1}	Vibrational frequency ν_1 cm^{-1}	Correspondence with solution bands of Pant and Khandelwal
S_1	(Normal)	20592	963	α
S_2	(I hydrolysed)	20288	819	γ
S_3	(II hydrolysed)	19183	825	δ
S_4	(III hydrolysed)	18898	820	δ.
S_5	(Acidic complex)	20690	864	α'

In view of the mechanism of hydrolysis as depicted for uranyl chloride the formations of acetate S_2 and S_3 are similar to those of chloride S_2 and S_3. But after the formation of $(UO_3\ UO_2)^{4+}$ in S_3, the polymerisation perhaps starts very rapidly to the formation of precipitates of species $(UO_3)n^{-}\ UO_2^{++}$ where n may have any value greater than 1. In fact in this laboratory[12],[13] has shown that many species do exist in the alkaline solutions of uranyl nitrate having different pH. The shifts in the electronic and vibrational energies of these higher polymerised hydrolytic species was found continuously to the lower values in small steps. It appears that acetate S_4 is one of these higher hydrolysed species.

SUMMARY

A detailed study of the changes in the spectrum of uranyl acetate under the various conditions of preparation of the samples revealed formation of hydrolytic species in solid state like in uranyl chloride on the one hand and also the formation of anionic complex like in alkali double acetates of uranyl on the other. It has been proved that the energy shifts of the electronic part on successive hydrolysis in case of chloride and acetate are not only qualitaively but also quantitatively similar for I and II hydrolysed species with respect to the normal salts. The vibrational frequencies, however, change to a slightly smaller extent in acetates than in chlorides. The electronic energy on anionic complexing changes to the higher values relative to that of the normal salt in agreement

with earlier observations in connection with solutions as by Pant and Khandelwal and in double acetates. The similarities of the hydrolytic species and anionic complexes in solutions and solids is further corroborated by the study of other properties such as temperature variation of fluorescence intensity and qualitative changes in the relative intensities in the absorption bands.

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REFERENCES

1. Nichols & Howes 1919. Fluorescence of uranyl salts, Carnegie Inst. Wash., pub. 298.
2. Pant 1945. *Proc Ind. Acad. Sci.*, **22** : 110.
3. Freymann et al. 1946. *Compt. rend.*; 223, 545.
4. Samoilov 1954. *Dok. Akad. Nauk. S. S. S. R.*, **98** : 99-102
5. Rao & Narsimham 1956. *Ind. J. Phys.*; **30** : 334.
6. Narsimham 1960. *Ibid.*, **34** : 321.
7. *Idem* 1960. *J. S. I. R.*, **19** (B) : 285.
8. Pant & Pandey 1957. *J. S. I. R.*, **16** (B) : 280.
9. Pande & Pant. 1967. *Agra Unin. Jour. Res.* (*Sci.*), **XVI** (III) : 101-120.
10. Pant & Khandelwal 1958. *Current Sci.*, **27** : 242.
11. Khandelwal 1859. *J. Sci. Res. B. H. U.*, **9** (2) : 66.
12. Pant & Bisht 1966. *Juor. Pure. and App. Phys.*, 1470.
13. Dieke & Duncan 1949. Spectroscopic properties of uranium compounds, Mc Graw Hill.

TABLE 1-a

Fluorescence bands at —185°C *of* $UO_2AC_2\ 2H_2O$ (S_1)

Group	cm^{-1}	Nature	Designation	Interpretation
I	20592	st, sh	B_0 (F_0)	resonance band
	20560	w, sh		
	20510	w, d		
	20576	w, d		
	20449	w, d		
	20423	w, d		
	20387	w, d		
	20364	w, sh	E_0	$F_0 - 259$ (ν_2)
	20333	m, d	L	Lattice
	20292 20275	w, d	L′	Impurity
II	19974			
	19883			
	19727	v, st, d	B_1	$F_0 - 863$ (ν_1)

(*Contd.*)

TABLE 1-a (*Contd.*)

Fluorescence bands at —185°C *of* $UO_2AC_2\ 2H_2O(S_1)$

Group	cm⁻¹	Nature	Designation	Interpretation
	19646	st,d	C_1	$F_0-946\ (\nu_3)$
	19615			
	19577			
	19552			
	19517			
	19493			
	19471	m,d	E_1	$F_0-\nu_2-\nu_1$
	19429 19414	w,d	L′	Impurity
	19292	v,w,d		
III	19115	w		
	19024	w		
	18867	st,d	B_2	$F_0—\nu_2\ \nu_1$
	18792	st,sh	C_2	$F_0—\nu_3-\ \nu_1$
	18778	w,d	L	
	18753	w,d		
	18698			
	18657			
	18634			
	18608	w,d	E_2	$F_0—\nu_2—2\ \nu_1$
	18566 18550 18427	w,v,d	L′	Impurity
IV	18255			
	18167			
	18013	st,sh	B_3	$F_0—3\ \nu_1$
	17942	st,sh	C_3	$F_0—\nu_3—2\ \nu_1$
V	17161	st,sh	B_4	$F_0—4\ \nu_1$
	17093	st,sh	C	$F_0—\nu_3—3\ \nu_1$

N.B.—v, very ; w, weak ; d, diffuse : m, medium ; st, strong ; sh, sharp.

TABLE 1-b

Absorption band of $UO_2AC_2\ 2H_2O(S_1)$ *at* —*185*°C

cm^{-1}	Nature	Designation	Interpretation
20592	st, sh	b_0 (F_0)	resonance line
20619	w		
20757	w, v, d		
20944	m, v, d		
21245	m, sh	M_0	magnetic series
21290	w, sh	b_1 (F_1)	F_0+698 (ν_1)
21323	st, sh	b_1 (F_1)	F_0+731 (ν_3)
21351	w, sh		
21480	w, d		
21513			
21554			
21693			
21634			
21940	m, sh	M_1	M_0+695 (ν_1)
21968	st, sh	M_1	M_0+723 (ν_3)
22002	v, w		
22022	w, sh	b_2 (F_2)	$F_0+\nu'_1+\nu'_3$
22053	st, sh	b_2 (F_2)	$F_0+2\ \nu'_3$
22197	w, d		
22316	m, sh		
22435	st, d	D_o	diffuse series
22585	w, d		
22665	w, d	M_2	$M_0+\nu'_1+\nu'_3$
22694	w, sh		
22719	w, sh		
22783	m, sh	b_3 (F_3)	$F_0+3\ \nu'3$
23154	v, st, d	D_1	D_0+719 ($\nu'3$)
23355	st, d	D'_1	D_1+201
23874	v, st, d	D_2	$D_0+\nu'3$

(*Contd.*)

TABLE 1-b (*Contd.*)

Absorption band of $UO_2AC_22H_2O(S_I)$ *at —185*°C

cm^{-1}	Nature	Designation	Interpretation
24077	st,d	D'_2	$D_1+\nu'3$
24577	st,d	D_3	
24793	st,d	D'_3	
25285	st,d	D_4	
25503	st,d	D'_4	
26006	m,d	D_5	
26221	st,d	D'_5	
26650	m,sh	U_0	Ultraviolet series
27123	m,sh		
27347	w,sh		
27381	m,sh	U_1	U_0+731 ($\nu'3$)
27870	m,sh		
28122	w,sh	U_2	

TABLE 2-a

Fluorescence bands of acetate (*I hydrolysed*) S_2 *at 185*°C

Group	cm^{-1}	Nature	Designation	Interpretation
I	20288	st,sh	B_0 (F_0)	resonance band
	20274	w,sh		
	20031	v,w	E_0	F_0—257 (ν_2)
II	19439	st,sh	B_1	F_0—849 (ν_1)
	19425	w,sh		
	19349	v,w	C_1	F_0—939 (ν_3)
	19183	v,w	E_1	$F_0-\nu_2-\nu_1$
III	18590	st,d	B_2	$F_0-2\nu_1$
	18576	w,d		
	18501	v,w	C_2	$F_0-\nu_3-\nu_1$
	18334	v,w	E_2	$F_0-\nu_2-2\nu_1$
IV	17742	w,d	B_3	$F_0-3\nu_1$
	17661	v,w	C_3	$F_0-\nu_3-2\nu_1$
V	16896	w,d	B_4	$F_0-4\nu_1$

TABLE 2-b

Absorption bands of acetate S_2 *at* $-185°C$

cm^{-1}	Nature	Designation	Interpretation
20274	w, sh	b_0 (F_0)	resonance band
20288	st, sh		
20591	w, sh	impurity	F_0+310
20993	w, sh	b_1 (F_1)	F_0+721 (ν'_3)
21009	st, d		
21270	w, v, d	M_0	magnetic series
21299	w, d		
21690	w, sh		
21709	w, sh	b_2 (F_2)	$F_0+2\ \nu'_3$
21725	st, sh		
21992	m, d	M_1	M_0+722
22379	m, d	D_0	diffuse series

TABLE 3

Fluorescence bands of acetate (hydrolysed II) S_3 *at 185°C*

Group	cm^{-1}	Nature	Designation	Interpretation
I	19183	w, sh	B_0 (F_0)	resonance band
	18947	m, v, d	E_0	F_0-236 (ν_2)
II	18358	st, d	B_1	F_0-825 (ν_1)
	18270	st, d	C_1	F_0-913 (ν_3)
III	17534	m, d	B_2	$F_0-2\ \nu_1$
	17459	m, d	C_2	$F_0-\nu_3-\nu_1$
IV	16715	w, d	B_3	$F_0-3\ \nu_1$
	16641	w, d	C_3	$F_0-\nu_3-2\ \nu_1$

TABLE 4

Fluorescence band of acetate (hydrolysed III) S_4 *at* $-185°C$

Group	cm^{-1}	Nature	Designation	Interpretation
I	18898	v, d	B_0	resonance band
II	18078	v, d	B_1	B_0-820 (ν_1)
III	17252	v, d, w	B_3	$B_0-2\ \nu_1$

TABLE 5-a

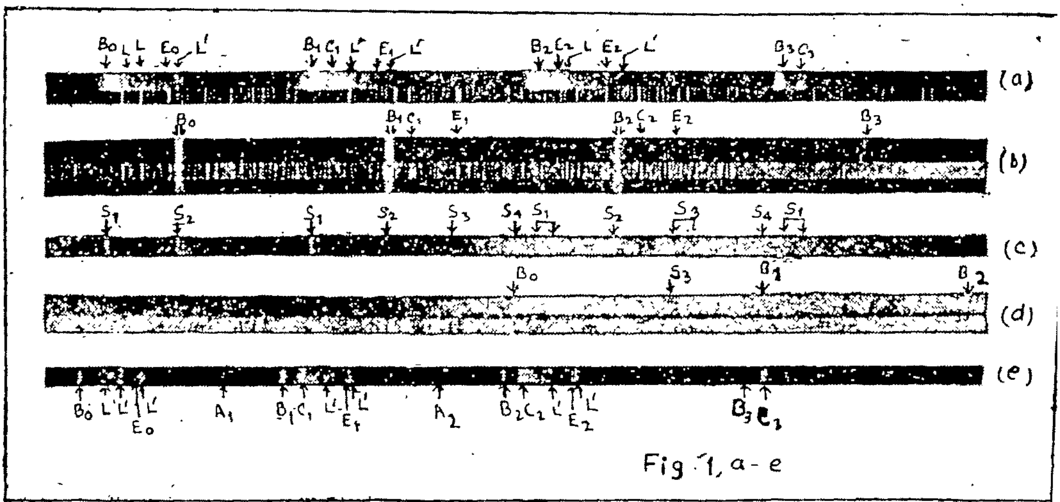
Fluorescence bands of acetate (acidic complex) S_5 *at* $-185°C$

Group	cm^{-1}	Nature	Designation	Interpretation
I	20858	w		
	20785	w		
	20690	st, sh	B_0 (F_0)	resonance band
	20628	w		
	20578	m, d	L	ligand (112)
	20559	w		
	20536	w		
	20511	st, sh	L	ligand (179)
	20434	w	E_0	$F_0-\nu_2$ (256)
	20418	st, sh	L′	ligand (272)
II	20073	m, sh	A_1	$F_0+244-\nu_1$
	20022	w, d		
	19990	w, d		
	19917	w, d		
	19826	st, sh	B_1	$F_0-\nu_1$ (864)
	19742	st, d	C_1	$F_0-\nu_3$ (948)
	19647	st, sh	L	
	19572	w, sh	E_1	$F_0-\nu_2-\nu_1$
	19556	st, d	L	
III	19211	m, sh	A_2	$A_1-\nu_1$
	18968	st, sh	B_2	$F_0-2\nu_1$
	18887	st, d	C_2	$F_0-\nu_3-\nu_1$
	18788	m, d	L	
	18711	w, sh	E_2	$F_0-\nu_2-2\nu_1$
	18697	m, sh	L	
IV	18350	w, sh	A_3	$A_1-2\nu_1$
	18112	w, sh	B_3	$F_0-3\nu_1$
	18032	m, d	C_3	$F_0-\nu_3-2\nu_1$
	17933	w, sh	L	

TABLE 5-b

Absorption bands of acetate (acidic complex) at —185°C

cm⁻¹	Nature	Designation	Interpretation
20690	w,sh	b_0 (F_0)	resonance band
20785	w,d	L	ligand
20858	w,d		
20934	st,d	a_0	F_0+244 (γ'_2)
21395	st,sh	b_1	$F_0+\nu'_1$ (705)
21421	w,sh	b'_1	$F_0+\gamma'_3$ (731)
21601	st,d	M_0	magnetic series
21664	w,d	a_1	a_0+730 (γ'_3)
21713	st,d	M'_0	magnetic series
22029	w,sh		
22058			
22088			
22116	st,sh	b_2	$F_0+2\ \gamma'1$
22280	st,d	M_1	
22325	w,d		
22391	st,d	M'_1	



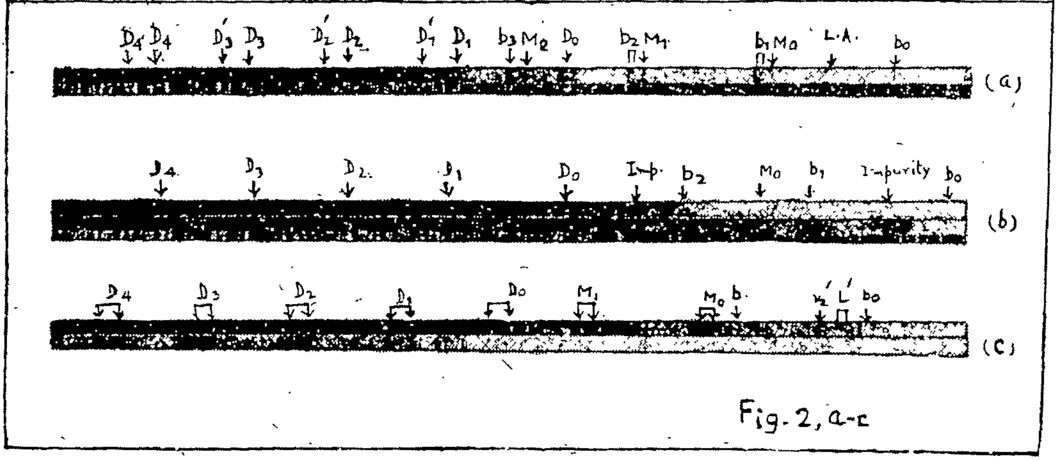


Fig. 1. Fluorescence spectra of various samples of uranyl acetate at —185°C (taking in grating) (a) original dihydrate, S_1, (b) precipitate on slow evaporation of aqueous solution, S_2: (c) S_1 exposed to atmospheric moisture; (d) precipitate on boiling aqueous solution, S_4 and (e) recrystallised with excess acetic acid, S_5.

Fig. 2. Absorption at —185°C, (a) normal salt S_1; (b) hydrolysed sample S_2 and (c) acidic complex, S_6.

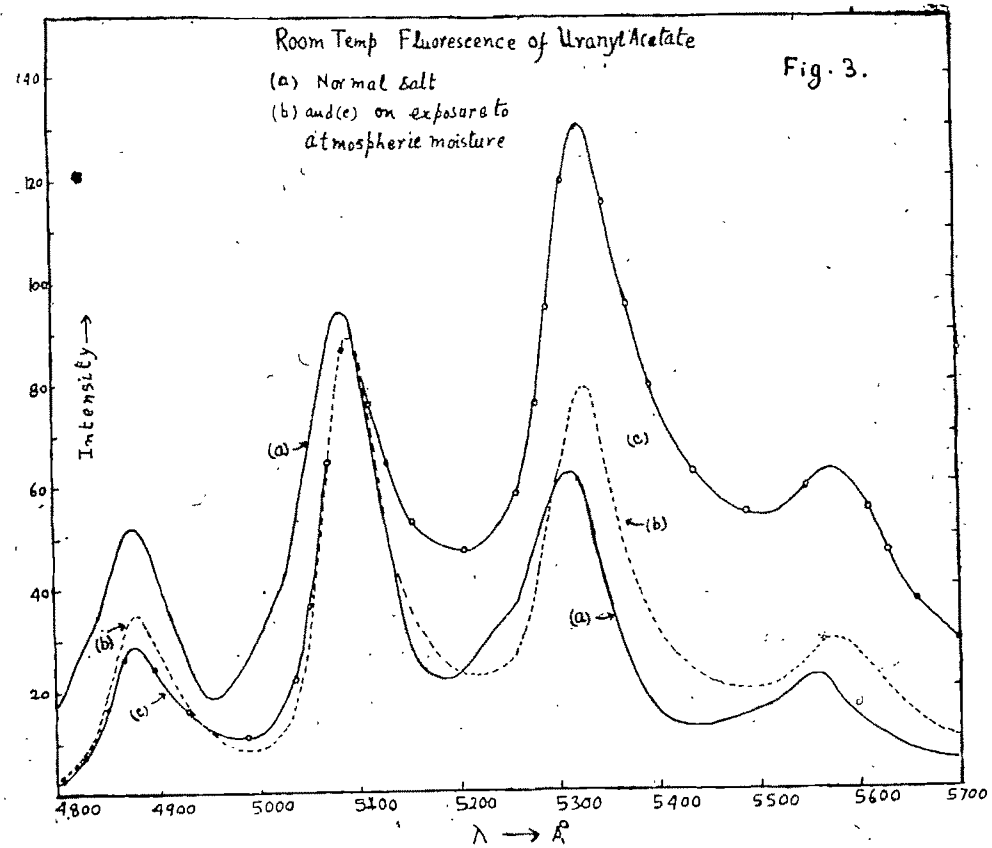


Fig. 3.

Room Temp Fluorescence of Uranyl Acetate
(a) Normal salt
(b) and (c) on exposure to atmospheric moisture
Intensity →
140
120
100
80
60
40
20
(a)
(b)
(c)
(a)
(b)
(c)
(a)
4800
4900
5000
5100
5200
5300
5400
5500
5600
5700
λ → Å

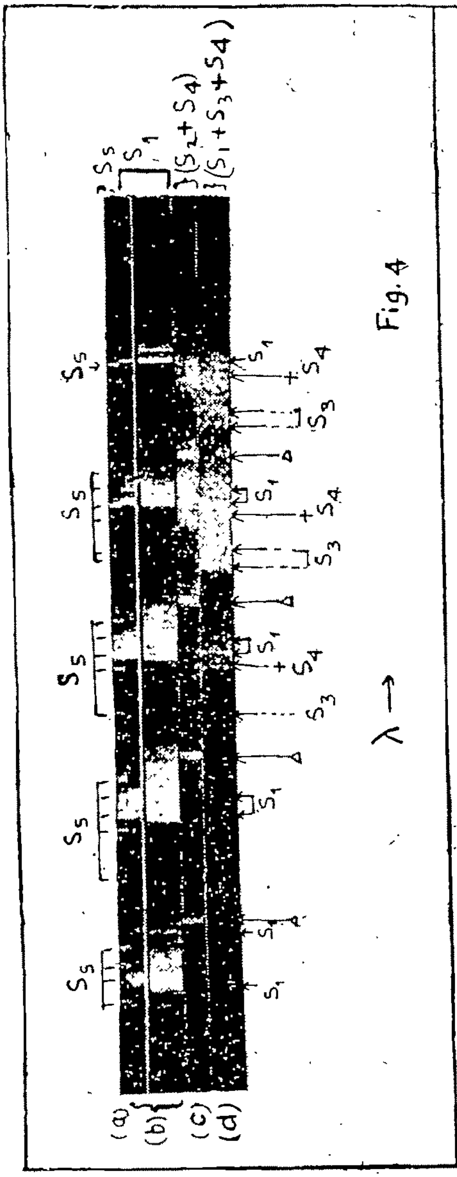


Fig. 4

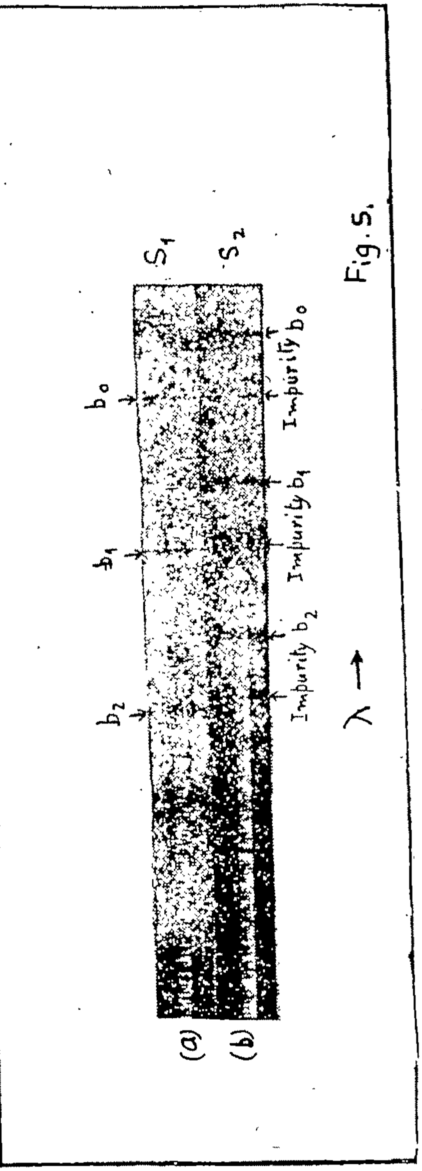


Fig. 5.

Fig. 4. Fluorescence spectra of various samples of acetate at −185°C (large prism spectrograph Hilger).

Fig. 5. Absorption spectra of acetate S_1 and S_2 at −185°C (large prism spectrograph Hilger).

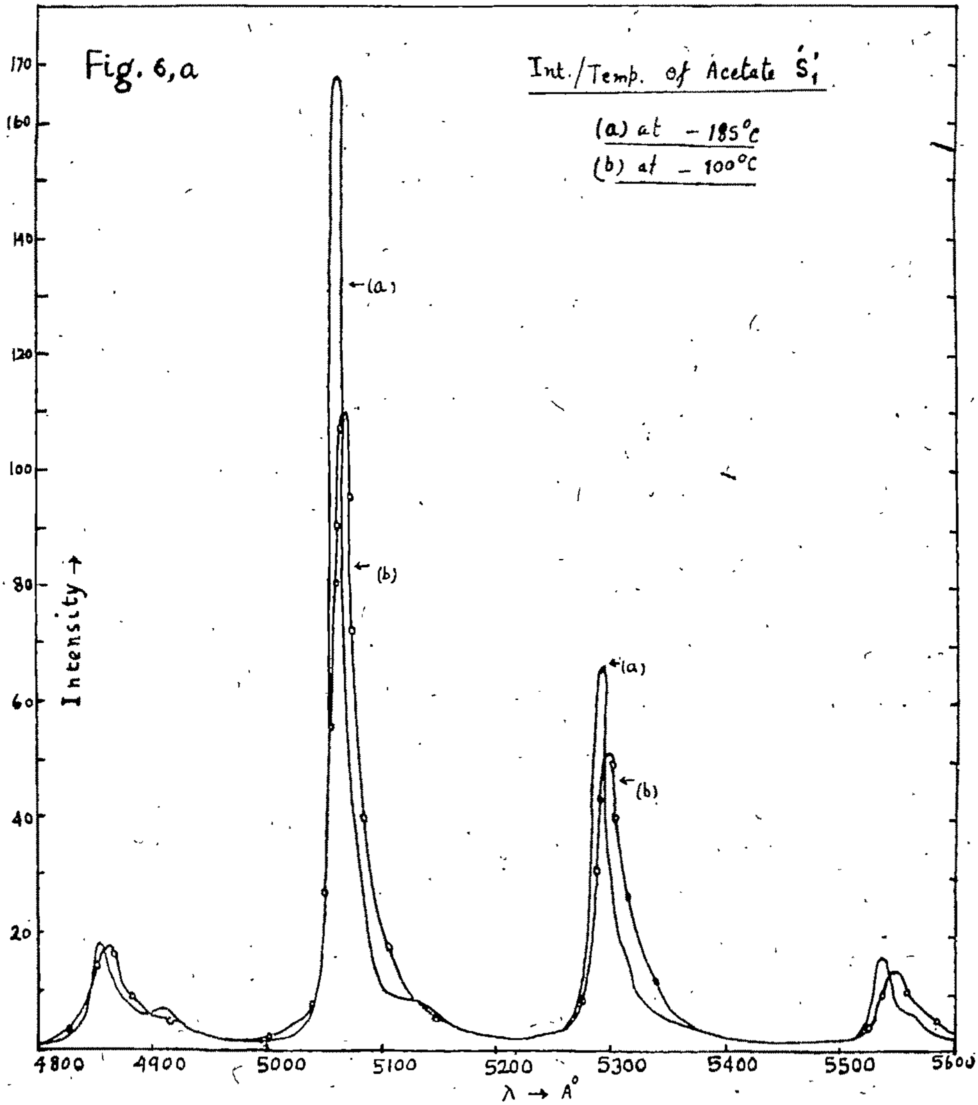
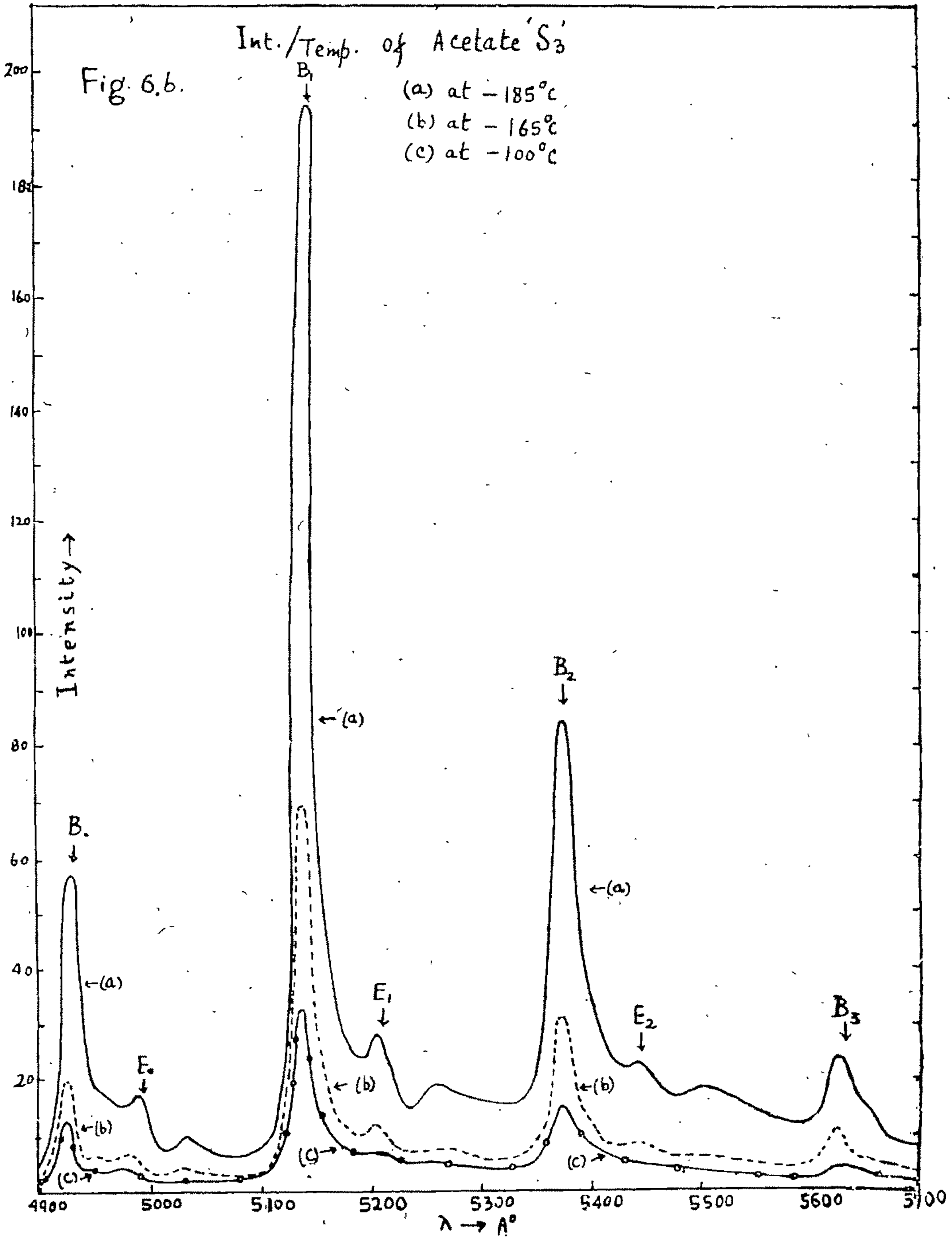


Fig. 6,a

Int./Temp. of Acetate S'₁
(a) at -185°c
(b) at -100°c
←(a)
←(b)
←(a)
←(b)
Intensity →
170
160
140
120
100
80
60
40
20
4800
4900
5000
5100
5200
5300
5400
5500
5600
λ → A°


Int./Temp. of Acetate 'S₃'
Fig. 6.6.
(a) at −185°c
(b) at −165°c
(c) at −100°c
Intensity →
λ → A°
B.
B₁
B₂
B₃
E₀
E₁
E₂
←(a)
←(b)
(c)→
200
180
160
140
120
100
80
60
40
20
4900
5000
5100
5200
5300
5400
5500
5600
5700

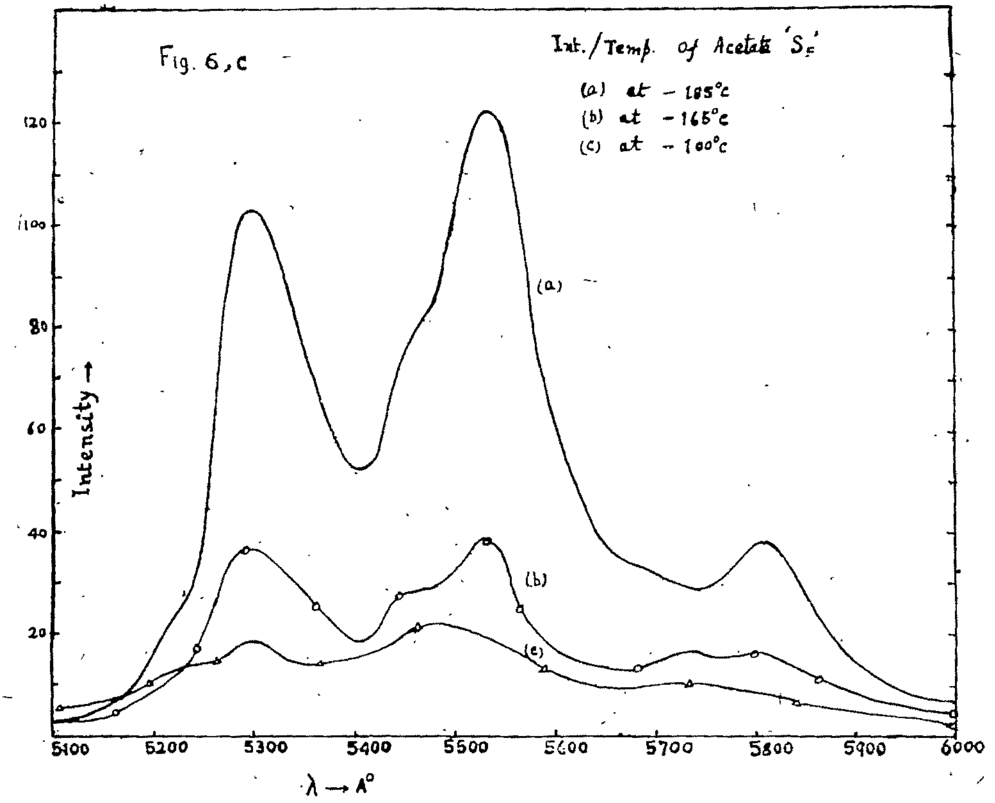


Fig. 6, c
Int./Temp. of Acetate 'S'
(a) at -185°c
(b) at -165°c
(c) at -100°c
Intensity →
120
100
80
60
40
20
(a)
(b)
(c)
5100
5200
5300
5400
5500
5600
5700
5800
5900
6000
λ → A°

STUDIES ON THE EFFECT OF HIGH ENVIRONMENTAL TEMPERATURE ON THE PHYSIOLOGICAL RESPONSE OF BUFFALO

PART III. SERUM PROTEIN CONTENT OF BUFFALO COWS EXPOSED TO SUMMER CONDITIONS.

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The functions of plasma protein in holding adequate percentage of water as intravascular fluid and in maintaining viscosity of blood, are, amongst other factors, important in thermoregulation and combating heat stress. It provides an efficient way of transferring the heat from inside the body to the outer surface of the skin for dissipation. Many other functions of plasma protein, for example, those in relation to the maintenance of acid-base equilibrium, the suspension stability of erythrocytes, body protein transportation, the mechanism of blood clotting and immunity, enhance their significance during the stress caused by adverse climatic conditions (Kamal *et al.*, 1962). In a study aimed at assessing the heat acclimatization of buffalo the variations in the plasma (or serum) proteins and their fractions were investigated; the results obtained have been reported in this communication.

MATERIALS AND METHODS

The investigation was carried out during April, May and June, which represent the hottest part of the year at Mathura. The selection, housing and management of the two groups of animals utilized in this study and the methods adopted for determining the climatic elements obtaining within and outside the experimental house have been described in Parts I and II of the series. (Pandey & Roy, 1968 b & c).

Blood samples were drawn from each animal at 3 p.m. once in a month. Total serum protein content was determined by the Micro-Kjeldahl method as given by Hawk *et al.* (1954). Fractionation of serum protein was done by paper electrophoresis in a Carl-Zeiss separating cell. Veronol acetate buffer system of ionic strength 0·05 and pH 8·6 was used for electrophoresis. The separation was carried out over a period of 16 hours, using 90 volt current with a flow of one milliampere per strip. The strips were stained by the technique of Block *et al.* (1958) and the final development was carried out as advised by Jencks *et al.* (1955). The finished pherograms so obtained were evaluated from the diagram drawn on Carl-Zeiss Extinction Recording Instrument with integrator. The relative concentration of proteins was determined by drawing distribution curves based on the quantitative principle of Grassmann and Haning (1950) and actual amount of different proteins was calculated from their percentage in the total serum protein.

The statistical analysis was carried out according to the methods recommended by Snedecor (1956).

RESULT

The concentration of the total serum protein and its fractions, in the two groups of buffalo cows had been shown in the table.

TABLE 1

Concentration of total serum protein and its fractions in unprotected (U) and protected (P) buffalo cows during summer months.

Attributes	Group	April	May	June	Seasonal average and S. E.
Total serum	U	7·14±0·15	7·93±0·35	8·51±0·23	7·86±0·190
Protein g/100 ml.	P	7·75±0·19	7·95±0·32	7·47±0·22	7·72±0·140
Serum albumin	U	2·29±0·17	2·45±0·13	2·66±0·11	2·47±0·073
g/100 ml.	P	2·65±0·17	2·49±0·09	2·44±0·08	2·53±0·066
Total globulins	U	4·85±0·28	5·48±0·24	5·85±0·27	5·39±0·152
g/100 ml.	P	5·09±0·20	5·46±0·26	5·02±0·17	5·19±0·110
Alfa-globulin	U	1·28±0·08	1·43±0·07	1·48±0·04	1·40±0·040
g/100 ml.	P	1·29±0·07	1·34±0·07	1·21±0·09	1·28±0·043
Beta-globulin	U	0·87±0·05	0·90±0·08	1·00±0·10	0·93±0·044
g/100 ml.	P	0·75±0·01	0·85±0·05	0·74±0·04	0·79±0·024
Gamma-globulin	U	2·69±0·09	3·14±0·10	3·37±0·20	3·07±0·100
g/100 ml.	P	3·03±0·10	3·27±0·18	3·07±0·09	3·12±0·074

During April the total serum protein content was significantly less ($P \angle 0{\cdot}05$) in the unprotected animals compared to the protected. However, a continuous rise was observed during May and June in the unprotected group and significant difference ($P \angle 0{\cdot}01$) was noted between the concentrations observed in April and June. In the protected group, after a slight increase during May, there was a decline in June and the resulting concentration was significantly less ($P \angle 0{\cdot}01$) than that for the unprotected group. Although the pattern of variation in the concentration of total and gamma-globulins was similar, significant difference ($P \angle 0{\cdot}05$) was observed between the two groups in the concentration of total globulin during June and between April and June concentration within the unprotected group. The gamma-globulins concentration varied significantly ($P \angle 0{\cdot}05$) between groups in April and in unprotected group between April and May and April and June. The albumin level which was higher in the protected group during April, showed a gradual fall during May and June, while in the unprotected group there was a continuous rise in the concentration and the June value was higher than that observed in the protected group. Statistical analysis showed that the variations were non-significant. The alfa-globulins concentration was similar in the two groups during April. The value in the unprotected group showed an increase during May and June but in protected animal it showed a decline. Significant differences ($P \angle 0{\cdot}05$) were observed between groups during June and in the unprotected group between April and June. For the beta-globulins the values were significantly ($P \angle 0{\cdot}05$) higher in the unprotected group from April through June than that observed in the protected. The variations have been graphically illustrated in Figure 1.

DISCUSSION

Because heat acclimatization has been found to be associated with simultaneous increase in blood plasma and interstitial fluid (ISF) volume (Bass and Hanschel, 1956) and since serum protein influences the water retaining capacity of animals, the higher concentration of serum protein (7·14 to 8·51 g/100 ml.) observed in buffalo cows would favour heat regulation under hot conditions. Pertinent in this connection is the report by Kamal *et al.* (1958) that the plasma protein concentration (7·13 g per cent) in 80°F reared heifers (heat acclimatized) was higher compared to 50°F reared heifers (6·43 g per cent). Under the management practices followed in this study, a progressive increase in the plasma and ISF volume in buffalo cows exposed to summer conditions and their corresponding decrease in the protected animals had been observed by Pandey and Roy (1968a); they found 15 and 11 percent higher plasma and ISF volume respectively in the unprotected animals compared to protected. Because proteins are the only osmotically active substance at the plasma—ISF interface, the relatively higher plasma volume can now be reasonably accounted for on the basis of the increase observed in the serum protein concentration of the unprotected animals as the summer progressed and vice versa in the protected animals.

SUMMARY

Variation in the serum protein and its fractions were studied in buffalo cows protected from and exposed to summer conditions.

Since serum protein influences the water retaining capacity of animal, the higher concentration (7·14 to 8·51 g/100 ml.) in buffalo cows would favour heat regulation under hot conditions. Increase in the serum protein concentration of the unprotected animals as the summer progressed and vice versa in the protected animals explain the adaptive changes in the extra-cellular fluid.

ACKNOWLEDGEMENT

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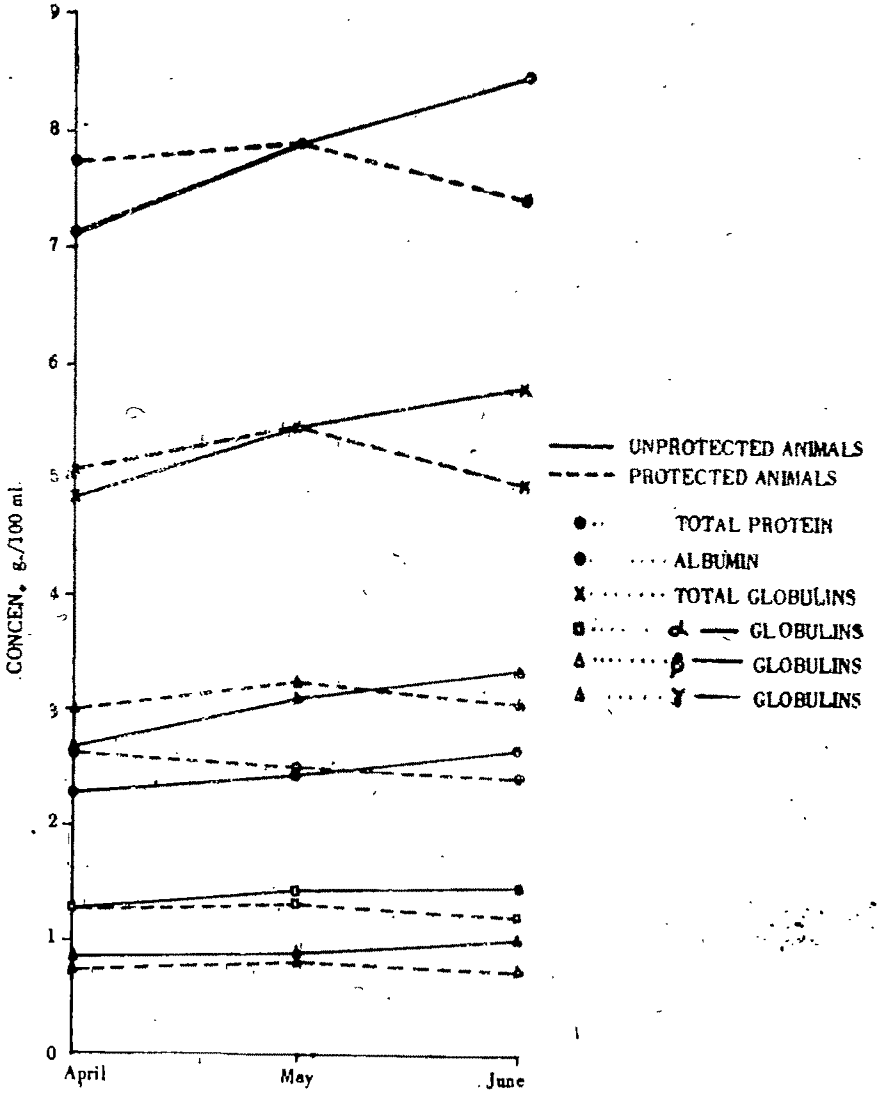
REFERENCES

1. Bass, D.E. & Hanschel, A. 1956. *Physiol. Rev.*, **36** : 128.
2. Block, R.J., Durrum, E.L. & Zweig, G. 1958. A manual of paper chromatography and paper electrophoresis, Academic Press, New York.
3. Grassmann, W. & Haning, K. 1950. Naturiviss-Enschaften, **37** : 496. *Cited by Block et al.* 1958. A manual of paper chromatography and paper electrophoresis, Academic Press, New York.
4. Hawk, P B., Oser, B.L. & Summerson, W.H. 1954. *Practical Physiological Chemistry*, 13th Ed., Blakiston Co., New York.
5. Jencks, W.P., Jetton, M.R. & Durrum, E.L. 1955. *Biochem. J.*, **60** : 205.
6. Kamal, T.H. Johnson, H.D. & Ragsdale, A.C. 1958. *J. Anim. Sci.*, **17** : 1227.
7. Kamal, T.H., Johnson, H.D. & Ragsdale, A.C. 1962. *Mo. Agric. Expt. Sta. Res. Bull. No.* 785.
8. Pandey, M.D. & Roy, A. 1968a. Symposium "Adaptation to hot and cold" *Ind. Science Cong. Assoc.*
9. Pandey, M.D. & Roy, A. 1968b. *Agra Univ. J. Res.* (*Sci.*) **17** (I) : 1-10.
10. Pandey, M.D. & Roy, A. 1968c. *Agra Univ. J. Res.* (*Sci.*) **17** (II) : 29-34.
11. Snedecor. G.W. 1956, *Statistical Methods*, Iowa State College Press, Iowa.

Variation in the concentration of serum protein and its fractions in unprotected and protected buffalo cows during summer.



LUMINESCENCE POLARISATION IN FLUORESCEIN ACTIVATED B_2O_3 GLASS

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Introduction

Polarisation of the radiation of Complex organic molecules was discovered in 1920 by Weigert[22]. Soon after the appearance of Weigert's paper a systematic study of the polarisation characteristic of luminescence was started by S. I. Vavilov and V. L. Levshin[20]. Polarisation characteristics of luminescence are now widely used for investigating the properties of matter[4,16,17] viz., structure in an isolated state and during interaction with the surrounding medium. This study is also helpful in establishing the nature of the radiators in crystal luminescence, i. e. magnetic dipole, quadrupole or electric dipole nature of the emitter. Recently polarisation studies have been applied to know the mechanism of non-radiative process present during the luminescence emission[2]. McConell[11], McRae[1], and Kasha[7] have suggested that the change in polarisation characteristic can be used to study the formation of molecular aggregates.

Luminescence polarisation depends on the parameters characterising the luminescence of a molecule itself i. e. the life time τ of the excited state, the molecular volume V and the other parameters characterising the medium i. e. viscosity η and temperature T and some other non-radiative processes. The non-radiative processes dealing with dissipation of the energy of the excited molecule into thermal energy have assumed considerable importance during recent years. The usual methods used to investigate these phenomena are the measurements of the life times and quantum yields. There have also been some attempts in correlating the line widths and line shifts with the non-radiative processes. Measurements of polarisation in respect of its relation with the non-radiative processes have not been pursued to any desirable extent. In this laboratory investigation of non-radiative processes are being carried out by measuring the life times[12] and relative quantum yields.[13] The present investigation was undertaken to supplement the data obtained by these methods.

Fluorescein in B_2O_3 glass is one of the earliest to be studied for various luminescence effects yet the data available for the polarisation in this system[10,23] are by no means complete. New observations on the nature of α phosphorescence have been reported by some workers where in the nature of the emitting state appears to be in conflict with earlier ideas. It was therefore of interest to study the influence of concentration, temperature and exciting wavelength on the luminescence polarisation, in the various parts of the emission spectrum namely fluorescence, α phosphorescence and β phosphorescence.

EXPERIMENTAL

The arrangement of the equipment used in the investigation is similar to reference 5 and is shown in figure 1. The light source S is a mercury lamp with required filter attachment. N_1 and N_2 are polariser and analyser respectively and L_1 and L_2 are the lenses. P is the phosphor used. M is the YM2 all purpose Monochromator. The receiver is 931 Photomultiplier tube. The signal is passed through a D. C. amplifier to multiflex galvanometer. This required D. C. amplifier to read the signal current of the order 10^{-12} amp. was fabricated in the Lab. The circuit diagram is given in fig. 2. The recording procedure consists of determining the meter deflection corresponding to the parallel I_{11} and the $I_{\perp}$ component of the luminescent light at different wavelengths. w. r. to the plane of polarisation of the exciting light.

The luminescence polarisation spectra of the phosphor excited by 3650A at L.T. (—180°C) and H.T. (120°C) for different concentrations (10^{-5}—10^{-3}) are shown in figs. 5 and 6. Spectra at R. T. for 4358 A excitation are shown in fig. 7.

DISCUSSION OF RESULTS

Lewis Lipkin and Magel[10] showed that at R. T. in the fluorescein activated boric acid glass, α band is equally polarised in the various parts of the emission spectrum while β band shows positive polarisation but never greater than few per cent when the sample was examined on the illuminated side. Pilpovich and Sveshnikov[14] found a difference in the degree of polarisation in β phosphorescence band in the various parts of the emission spectrum; of the phosphor. Gurinovich Sarzhevskli and Sevchenko[6],[18],[19] however showed variation of the degree of fluorescence polarisation in several organic phosphors on the frequencey ν_F of the region in the fluorescence spectra. This result is in contradiction with the data of the other investigators, S.I. Vavilov[21], Zanker Held and Rammansee[24] Eckart and Kuhn found polarisation P to be independent of ν_F Khochikov V. P. and Neporent[8] showed that the observed dependence of polarisation P on ν_F was a result of the presence in the sample of luminescence centers of different kinds.

Luminescence spectra of fluorescein B_2O_3 glass[15] at R. T. have generally 2 bands one at 4650-4800A and another at 5500A and a weak band around 5150A appears if care is not taken but is absent in dehydrated glasses. The shorter λ band is due to fluorescein cation F^+ while the 5500A band is due to β phosphorescence. In the presence of the middle band a shift is noted by Pant[15] in the α phosphorescence and fluorescence in the emission spectra. This band is to be avoided in studies on polarisation.

Luminescence polarisation spectra of the phosphor in different parts at R.T. are shown in fig. 3. The spectra show that in the part which corresponds to α phosphorescence coincident with fluorescence degree of polarisation remains constant. Also in the longer wavelength region β phosphorescence polarisation remains constant. In the middle region there is transition of degree of polarisation from higher value to lower in the direction of longer wavelength. The concentrational depolarisation is small in β band compare to the α band. The percentage of polarisation decreases slowly in the concentration range (10^{-5}—10^{-3}) and then at a dye conc. range (10^{-3} 10^{-1}) it begins to fall rather rapidly as shown in fig. 4 where p (percentage of polarisation) is plotted vs. log. C. (C-concentration).

At low temperature (—180°C) where α phosphorescence is absent, the concentrational depolarisation is negligible in the fluorescence and β phosphorescence bands. From this it is guessed that concentrational depolarisation of the α phosphorescence at R. T. ought to be larger than the depolarisation of the fluorescence in accordance with Sveshnikov[9]. Since the sign of the degree of polarisation for β phosphorescence band remains the same both at R.T. and L.T. which supplies the view that the β phosphorescence at all temperatures is caused from the same metastable state. From the Perrin Levshin. formula[4]

$$\frac{1}{P}=\frac{1}{P_0}+\left(\frac{1}{P_0}-\frac{1}{3}\right)\frac{RT}{V\eta}\,\tau \qquad \ldots(1)$$

where p_0 is the limiting value of the polarisation observed in the absence of rotational depolarisation ($\eta\rightarrow\infty$ $\tau\rightarrow 0$). The quantity P_0 is an empirical constant, V is the molecular vol. T is the temperature τ is the life time of the excited state. η is the viscosity of the medium. It follows that the degree of polarisation is larger at low temperatures (weaker Brownian motion), larger molecular volume, larger viscosity and lower life times[4] of the excited state. So we can guess that the factor $\frac{RT}{V\eta}$ τ as a whole does not change much with decrease in temp. in our glass, and hence increase in polarisation at —180°C is not observed, as in fig. 5. At high temp. 120°C in the spectrum there are three regions of different constant degree of polarisation but less than that at R.T. as in fig. 6. Here the middle region of constant degree of polarisation is guessed due to the newly developed fluorescence band[15] at 5200 A which has an absorption band at 4800 A. This band develops on irradiation of the sample also. The concentrational depolarisation is not observed at H. T. This absence can be explained easily; when the phosphor is heated its luminescence reduced as a result of quenching by the solvent which is accompanied by reduction in the life time τ of the excited state. Thus when the phosphor is heated the degree of polarisation decreases because of more vigorous translational brownian motion and increases owing to reduction in (a) rotational depolarisation and (b) concentrational depolarisation which occurs at high concentration and is associated with reduction in the lifetime of the excited state. At low concentration one can expect a reduction in the degree of polarisation with increasing temperature while at high concentration for which the second factor is decisive the opposite is the case. This is in agreement with our results.

At R.T. when the exciting wavelength 3650 A is changed to 4358A an appreciable increase in percentage of polarisation is observed in the long and shorter wavelength regions of the emission spectra as in fig. 7.

SUMMARY

The change in the degree of polarisation in the luminescence spectra of boric acid glass activated by Uranin at different concentrations $(10^{-5}-10^{-2})$ have been studied at room temperature liquid air temp. $-180°C$ and high temp. $+120°C$ with two different exciting wave lengths. It is observed that (a) polarisation spectra con ist of two bands at R.T. one in the lower wave length region characterised by high degree of polarisation and other in the longer wave length region characterised by small degree of polarisation (b) concentrational depolarisation is observed in the shorter λ region (α phosphorescence coincident with fluorescence) as also in the longer wave length band β phosphorescence (c) at 120°C temp. there are 3 bands with different constant degrees of polarisation for all the concentrations used. (d) at $-180°C$ temp. concentrational depolarisation is small in both fluorescence and β phosphorescence bands (e) by changing the exciting wave lengh from 3650A to 4358A an appreciable increase is observed in the degree of polarisation in both longer and shorter wave length regions of the emission spectra.

ACKNOWLEDGEMENTS

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REFERENCES

1. Bayliss, N.S. & Mc Rae, E. G. 1954. *J.C.P*, 58-1002.
2. Chaudhuri N. K. & Sayed. El. 1965. *J.C.P.* 42-6.
3. Eckhart, R. & Kuhn, H. 1960. *Z. Electrochem* , 64-356.
4. Feofilov, P.P. "The physical basis of polarised Luminescence" co sultant Bureau, New York 1961.
5. Gurinovich, G.P. & Sevchenko, A.N. 1959 *Opt. Spect.* 7-401
6. Gurinovich, G. P. & Sevchenko, A. N. 1958 *Izvest. Akad. Nauk. SSSR, Ser. Fiz* **22**: 1407
7. Kasha, M. 1960. F. O. Schmitt, *Bull Dept Bio. Mass. Inst. Tech.* Cambridge.
8. Khochkov, V. P. & Neporent, B.S. 1962. *Opt. Spect.* 12-125
9. Kudryashov, P. I. & Sveshnikov, B. Ya. 1960. *Opt. Spect.* 8-344.
10. Lewis, G. N.; Lipkin D. & Magel, T. T. 1941. *J.A. Chem. Soc.* 63-3005
11. McConell, H. 1952. *J.C.P.* 20-700
12. Pant, D.D. & Pant, H C. 1968. *Ind. J. Pure. And Appl Phys.* C-5-219.
13. Pant, D. D. & Tripathi, H.B. To be published in *Ind J. Pure. and Appl. Phys.*
14. Pilpovich, V.A. & Sveshnikov, B. Ya. 1958. *Opti. Spektr.*, 5-290
15. Pant, H.C. 1966. Thesis Agra University.
16. Rozenberg, G. V. 1959. *Opt. Spect.* 7-203.
17. Rozenberg, G.V. 1955. *Uspekhi. Fiz. Nauk* 56-77.
18. Sevchenko, A.N; Gurinovich, G. P. & Sarzhevskii, A. M. 1959. *Soviet, Physics. Doklady* 4-644.
19. Sevchenko, A. N.; Gurinovich, G. P. 1960. *Soviet. Physics.* Doklady 4-867.

20. Vavilov, S.I. & Levshin, V. L. 1923. *Zs. f. Physics*. 16, 136.
21. Vavilov, S.I. "Collected Works" 1952. **1**, *Izd. AN. SSSR.*
22. Weigert, F. Verh. D. 1920. Deutsch. Physics. Ges. (3) **1**.100.
23. Weissman & Lipkin, D. 1942. *J.A. Chem Soc.* **64**-1916.
24. Zanker, V. Held. M. & Rammensee, H. 1959. *Z. Naturforsch.* **14 B**-789.

Fig. 1

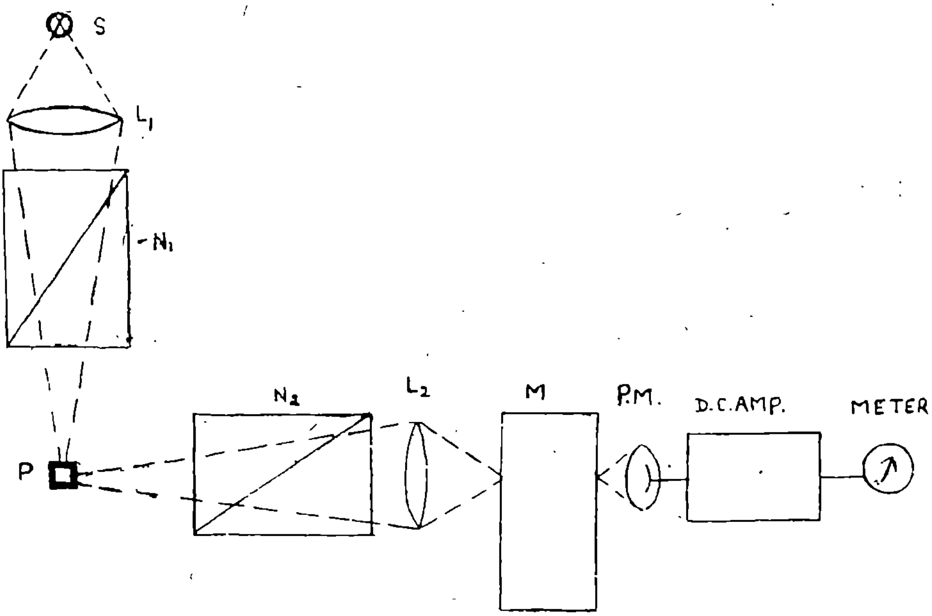


Fig.2

D. C. AMPLIFIER.

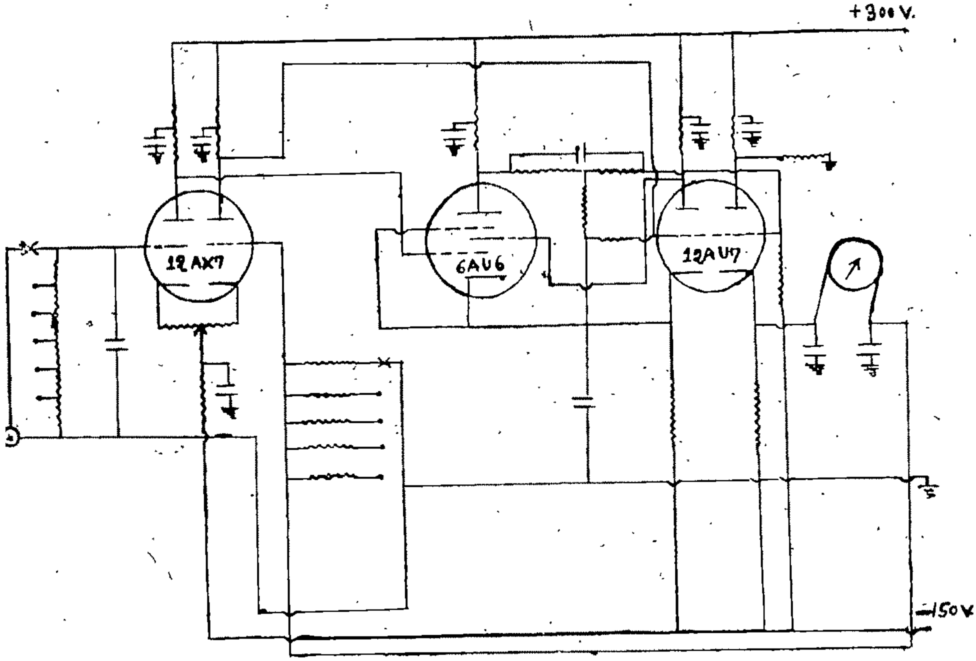


Fig. 3

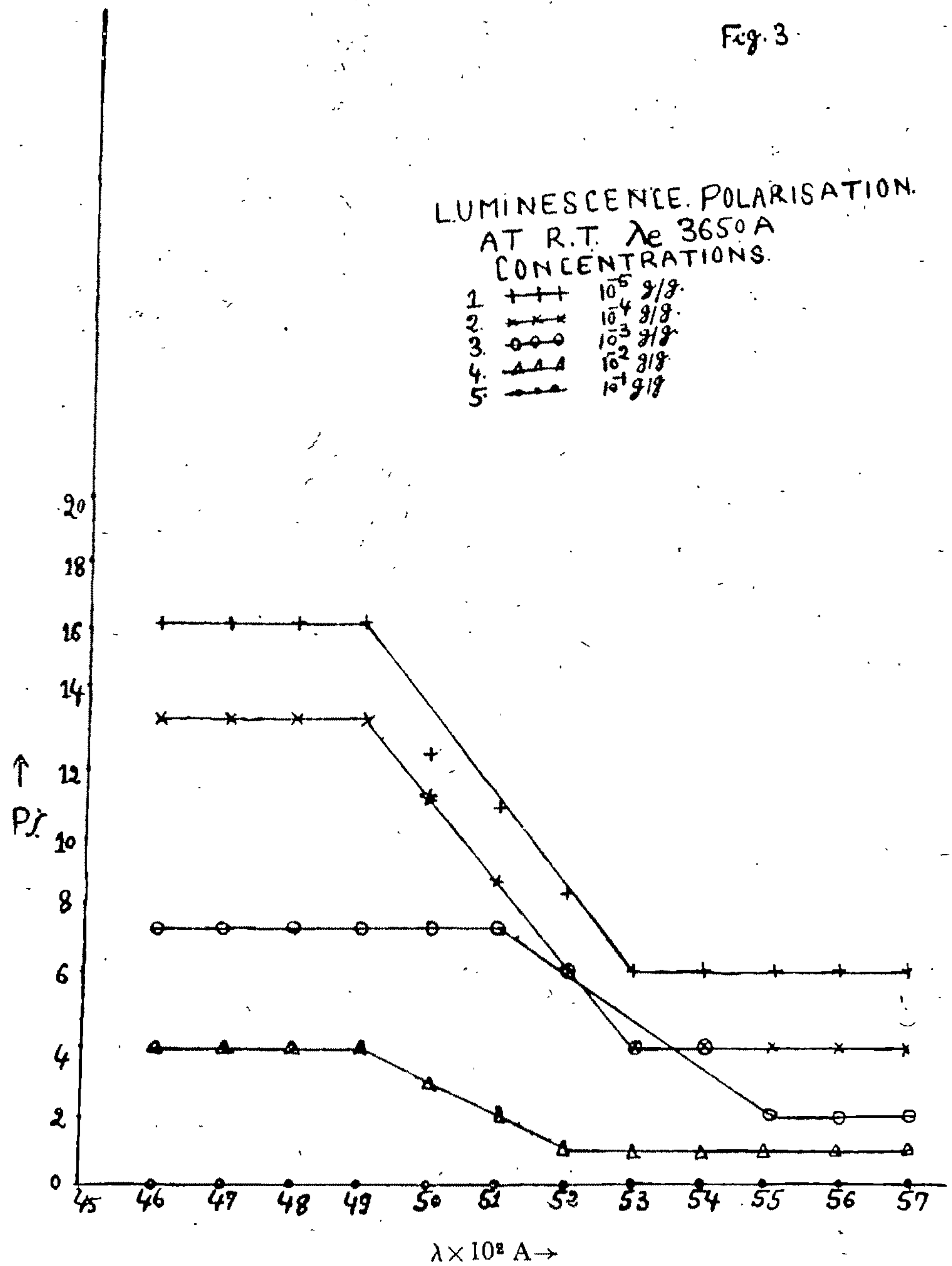

LUMINESCENCE. POLARISATION.
AT R.T. λe 3650 A
CONCENTRATIONS.
1 +++ 10⁻⁶ g/g.
2 ××× 10⁻⁴ g/g.
3 ooo 10⁻³ g/g
4 ΔΔΔ 10⁻² g/g
5 ••• 10⁻¹ g/g
↑ P%
0
2
4
6
8
10
12
14
16
18
20
45
46
47
48
49
50
51
52
53
54
55
56
57
λ×10² A→

Fig. 4.

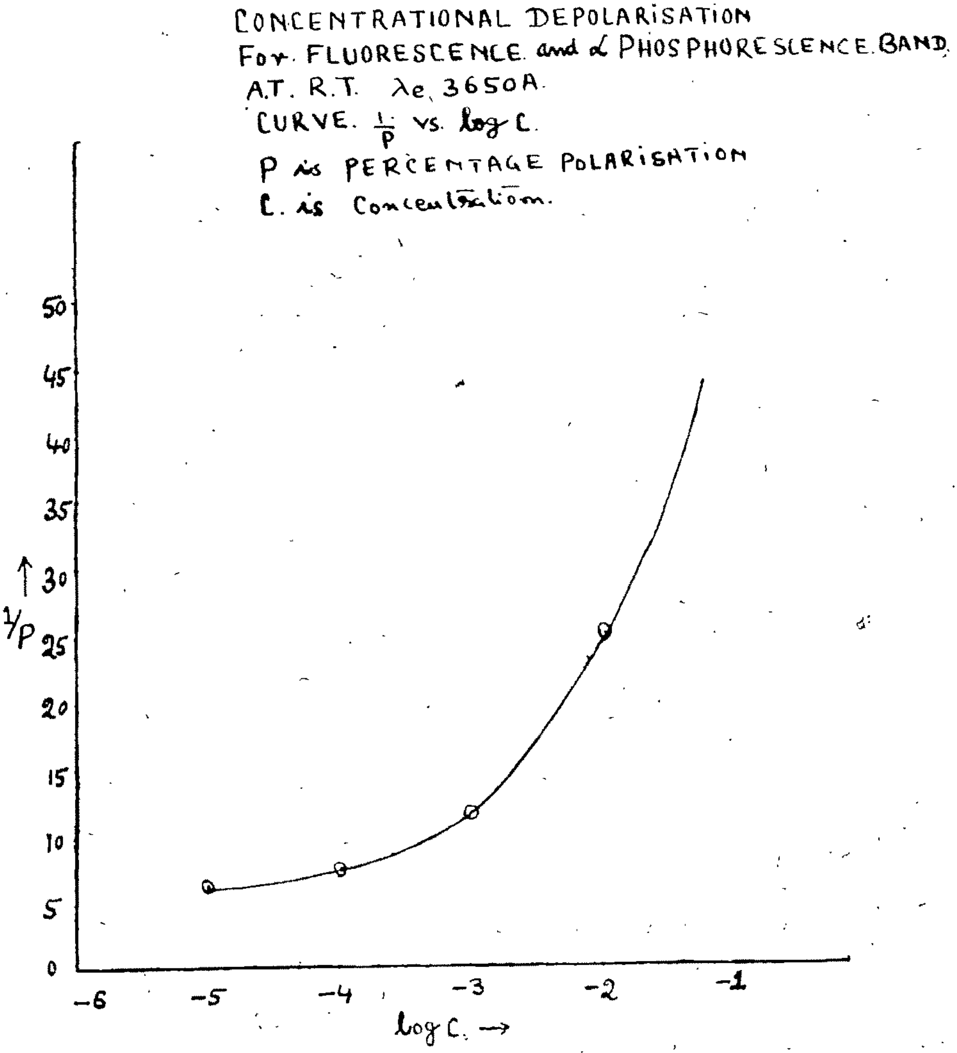

CONCENTRATIONAL DEPOLARISATION
For FLUORESCENCE and α PHOSPHORESCENCE BAND.
A.T. R.T. λe 3650A
CURVE. 1/P vs. log C.
P is PERCENTAGE POLARISATION
C. is Concentration.
50
45
40
35
30
1/P
25
20
15
10
5
0
-6
-5
-4
-3
-2
-1
log C. →

Fig. 5.

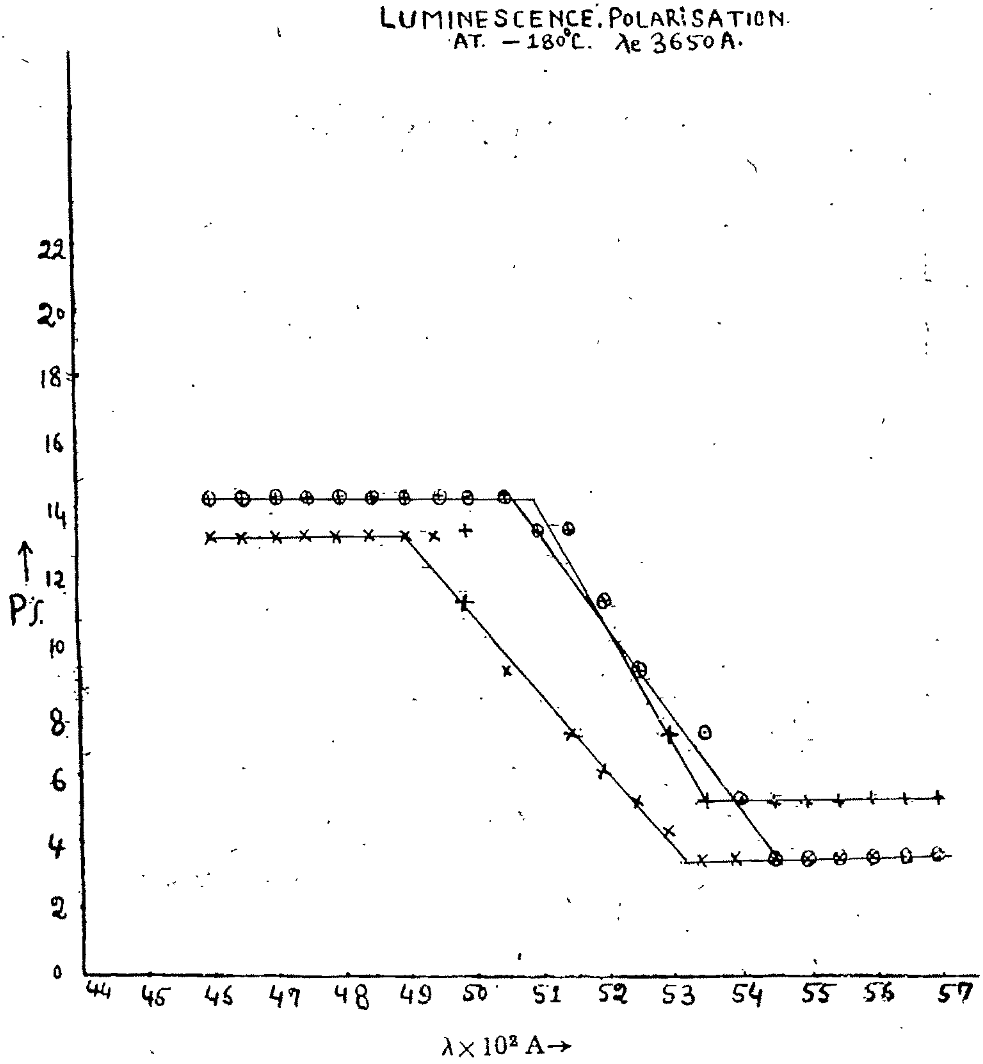

LUMINESCENCE. POLARISATION
AT. −180°C. λe 3650 A.
P%
0
2
4
6
8
10
12
14
16
18
20
22
44
45
46
47
48
49
50
51
52
53
54
55
56
57
λ × 10² A→

Fig. 6.

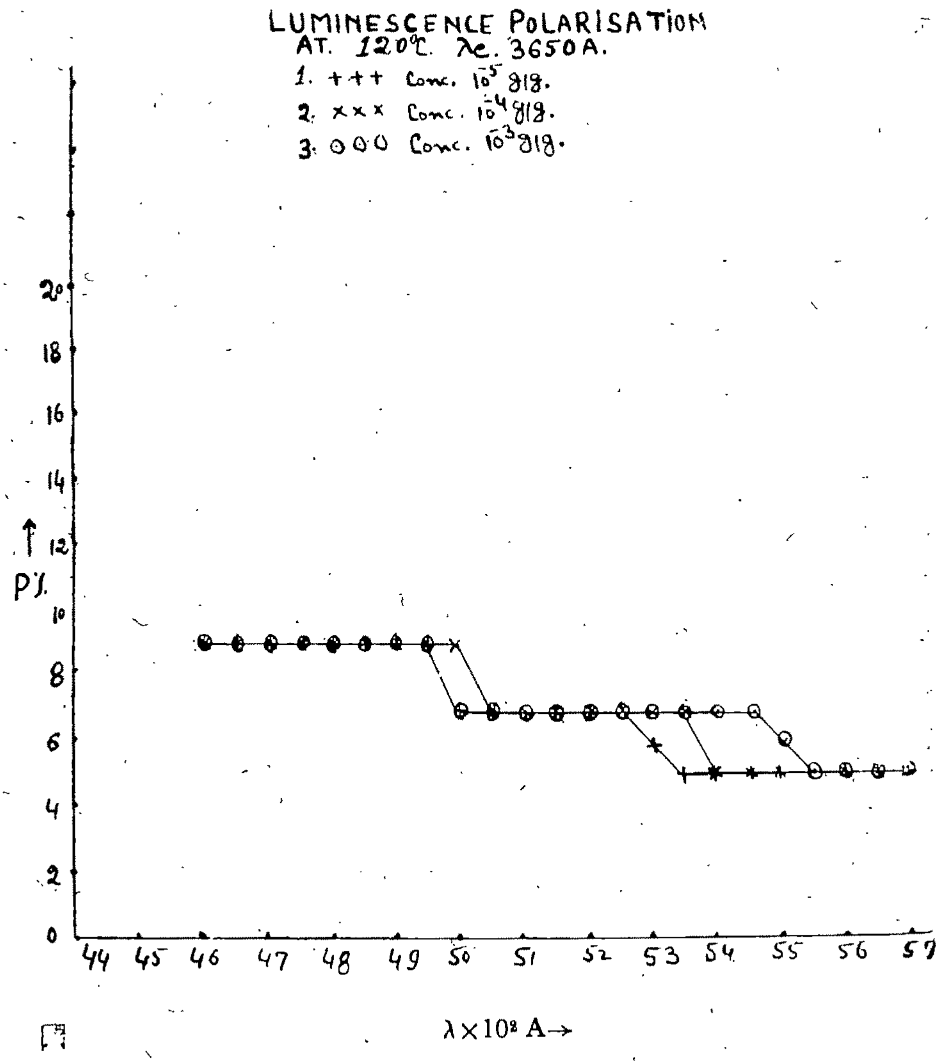
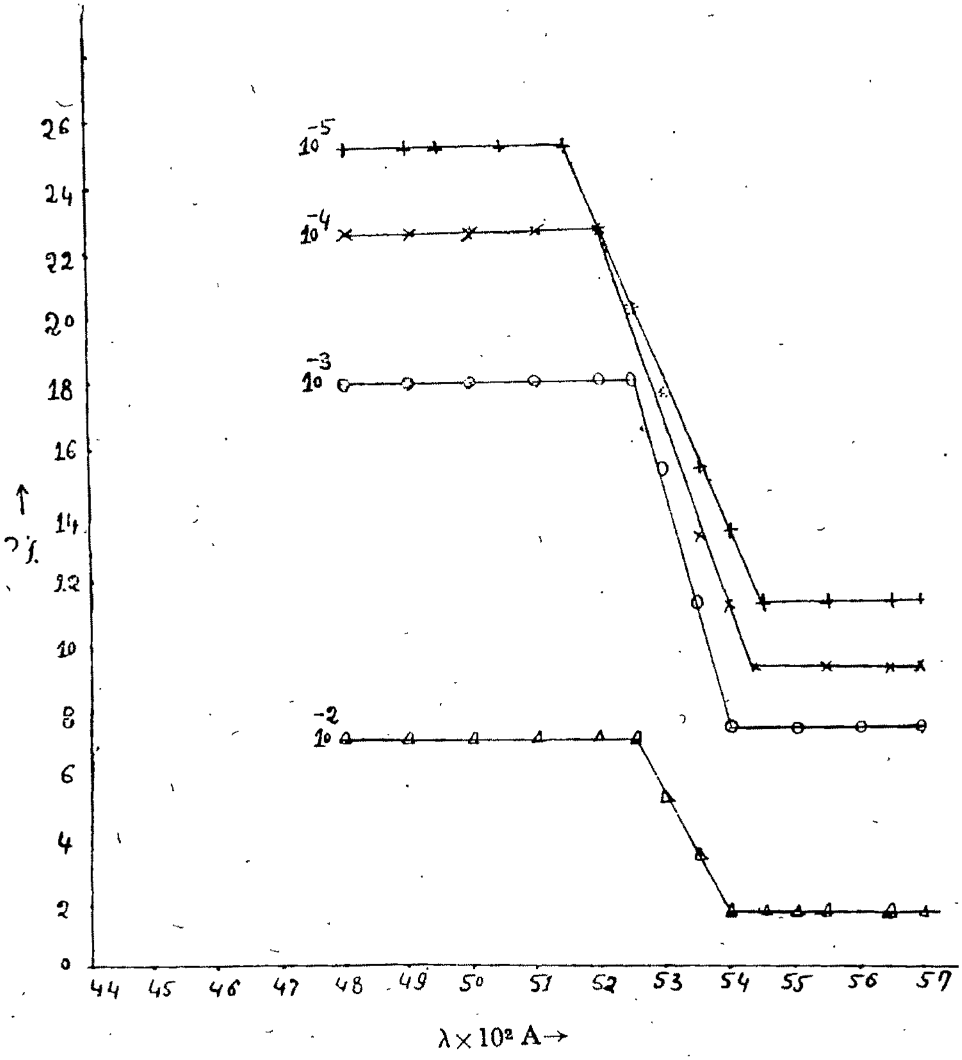

LUMINESCENCE POLARISATION
AT. 120°C. λe. 3650 A.
1. +++ Conc. 10⁻⁵ g/g.
2. ××× Conc. 10⁻⁴ g/g.
3. ○○○ Conc. 10⁻³ g/g.
↑ P%
20
18
16
14
12
10
8
6
4
2
0
44
45
46
47
48
49
50
51
52
53
54
55
56
57
λ×10² A→

Fig. 7.

LUMINESCENCE. POLARISATION.
AT. R.T. λe 4358A.



UPTAKE OF NITROGEN AND PHOSPHORUS BY PADDY UNDER WATER LOGGED CONDITION

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INTRODUCTION

It is needless to stress the importance of nitrogen and phosphorus in plant nutrition, more so in the case of paddy. Whereas nitrogen imparts a satisfactory ground growth, a deep green colour to plant leaves, the plumpness of grains and their protein percentage, phosphorus helps in cell division, formation of fat and albumin and in flowering and fruiting. Phosphorus counteracts the effectiveness of excess nitrogen and hastens maturity. It is also said to encourage the root growth, particularly the lateral and fibrous roots. It strengthens straw and reduces the possibility of lodging resulting from excess of nitrogen and increases grain to straw ratio in cereals.

The response of nitrogen and phosphorus to paddy crop is somewhat different than other cereal crops. Paddy is grown in soils which are usually submerged with water. The successful cultivation of paddy rather depends upon water logging condition and the abundant supply of water which brings a considerable change in the soil. Water-logging results in scarce supply of oxygen giving mostly an-aerobic decomposition of organic matter resulting the nitrogenous end-product of such decomposition mostly into ammonia, the form of nitrogen which is preferably utilized by paddy.

The behaviour of the phosphorus in the water-logged paddy soil is also distinct from non-water logged condition. Water-logging brings about a marked increase in the availability of phosphorus by reducing non-available ferric form of phosphate into available ferrous state depending upon the degree of water logging and the depth of standing water over the surface. The investigations carried out at Central Rice Research Institute, Cuttack revealed that water logging brought about a marked increase in the availability of phosphate in the paddy soils. The soil under water-logged condition may, therefore, be considered more fertile from the point of view of phosphate availability.

HISTORICAL

While studying the nutrient uptake by paddy at its different stages of growth, Kelley (1911) and Sen (1916) observed that all the nutrients are constantly absorbed upto flowering stage and after that absorption does not take place. On the other hand Gile and Carrero (1915) reported a continuous absorption upto harvest. Further on, Herrero (1924) reported a decrease in

N, P, K and S percentage of the plant with the increase in their age. It was observed by Breazeale (1928) that greater absorption of P_2O_5 takes place in presence of nitrogen. Further Lorenz and Johnson (1953) noted that ammonium sulphate increases P_2O_5 availability.

Sturgis and Read Fielding (1937), Chavan et al (1957) and Yates et al (1953) observed application of phosphorus to soil deficient in this nutrient resulted in better yield of rice. Raychaudhary (1952) and Satyanarayanum (1958) observed that when N and P were supplied in a balanced amount to paddy, a significant yield was obtained. Basak (1962) observed that the N and P uptake were strongly correlated with the grain yield.

EXPERIMENTAL

The experiment was conducted in pots in three replications using in each pot 12·5 lbs. surface 6″ soil from a newly broken land of the department and adding N and P @ 0,30 and 60 lb/acre singly and in combinations. For getting water logged condition in the pots, the drainage holes of the pots were plugged tightly. Thirty pre-soaked sprouted seeds of a medium variety paddy T_{100}, a bold seeded variety of vigorous growth, were sown per pot. When the seedling attained 6″ height the water was maintained to 3″ height throughout the experimental period.

First sampling of the soil, the standing water in the pot and of the growing plant was made on 30th day. Subsequent samplings were made on an interval of 21 days. Whereas the yield of rice per pot was taken separately for the three replication and analysed statistically, the chemical analyses of soil, water and plant were made on composite samples of the three replication.

NH_4-N and NO_3-N in soil and water was determined by MgO distillation and Davarda's alloy reduction method as described by Piper (1950). Available-P in soil (Troug's, 1930) and water was determined colorimetrically (Jackson 1962). Total nitrogen and phosphorus in plant samples were determined by the usual method as described by Piper (1950).

RESULT AND DISCUSSION

NH_4-N and NO_3-N in soil and standing water—It was observed that the NH_4-N and NO_3-N in the various treated soils ranged between 24-58 ppm and 62-90 ppm respectively. On comparing the values of NH_4-N and NO_3-N for different doses of phosphorus and nitrogen it is observed that the values for both increased with the increase in the doses of P and N. However, there was a general decrease in their values with the increase in the period of sampling. On the other hand there was practically no increase in the values of NO_3-N in soil samples with the increase in the dose of N as ammonium sulphate. It thus indicates that NO_3 form of N in the soil is not affected by fertilization of rice field with ammoniacal fertilizer. This may however be due to the fact that there is no nitrification under water-logged an-

aerobic condition, and also that rice prefers ammoniacal form of nitrogen. Like ammoniacal, nitrate-nitrogen showed a decrease with the increase in the period of sampling.

The value of NH_4-N in soil did not show appreciable decrease with the age of the crop upto a certain period. As this decrease in the level of NH_4-N is not sufficient to account for the nitrogen uptake by the plants under water-logged condition of the soil and as under inefficient supply of oxygen the conditions are not suitable for ammonium oxidation, one is led to conclude that some NH_4-N is being formed by the reduction of NO_3-N. This is further confirmed by the constant decrease in the value of NO_3-N with the increase in the days of sampling.

Available P in soil and water—The amount of available P in soil samples varied within the range of 24-62 ppm. It increased with the increase in the doses of N and P in the soil. When the values of available P in soil for the different doses of N and P are compared it is observed that there was a regular increase in the value of available P upto 72 days of the plant growth. This may be attributed to greater release of P than actually required by the plant at this stage. Basak and Bhattacharya (1962) also observed increased available P from planting to tillering stage and then a gradual drop to its original level.

The amount of available P in the standing water was between 6-13·5 ppm. It followed a close relation with the amount of available P in the soil.

Uptake of N by plant—It may be seen that the percentage of N in the crop was greater at the earlier stages of their vegetative growth which declined gradually with the advancement in the age of the crop. When the percentage of nitrogen in plant are compared for the different levels of phosphorus, it is observed that the uptake of N by plants increased with the increase in the dose of P.

Uptake of P by plant—Unlike that of nitrogen, the percentage of P in plant increased with the advancement in the age of plant upto 72 days of its growth. It then showed an abrupt decline which may be attributed to the movement of P to grain at this stage. It is also observed that like that of N, P-uptake by plants increased with the increase in the dose of P and also there was greater uptake to P with the higher dose of N, showing thereby an inter-relationship of N and P.

Yield and quality of grain and Straw—from the general condition of the plants it is observed that a combination of N and P showed better growth than either of them individually. A higher dose of N and P gave better response. It is further observed that 30 lb N and 60 lb P showed best effect and the interaction of the two factors jointly gave the best yield at $N_{30}P_{30}$. The values are highly significant with C. D. of 0·1908 for grain and 0·2982 for straw.

SUMMARY

A pot culture experiment on paddy under water logged condition using N and P at the rate of 0,30,60 lb/acre was laid out. It was observed that NH_4-N in the soil and the standing water increased with the increase in the dose of N and P. The value of available P increased upto 72 days of plant growth which also increased with the increase in the doses of N and P in the soil. It was further observed that the uptake of N and P by plants increased with the increase in the application of P and N respectively. The yield of paddy was highest at N_{30} P_{30} level.

REFERENCES

1. Basak, M. N. 1962. Nutrient uptake by rice plant and its effect on yield. *Agron, J.*, **54.** 373-376.
2. Basak, M. N. & Bhattacharya, R. 1962. Phosphate transformation in rice soil. *Soil Sci.*, **94**:258-262.
3. Breazeale, J.F. 1928. The effect of one element of plant food upon the absorption by plants of another element. *Tech. Bull. Agrizona Agri. Expt. Sta.*, **19**:465-480.
4. Chavan, V. M.; Gopalkrishna, N. & Sangave, R. A. 1957. Nitrogen and phosphate requirements of paddy crop. *Ind. J. Agro.*, **2**:95-100.
5. Gile, P. L. & Carrero, J. O. 1915. Ash composition of upland rice at various stages of growth. *J. Agri. Res.*, 5 (9):357-364.
6. Herrero, M. 1924. Cited from 'Rice' By Edwin Ringham copeland Mc Millian & Co., London pp. 15.
7. Jackson, M.L. 1962. Soil chemical analysis. Asia Publishing House, New Delhi.
8. Kelley, W. P. 1911. The assimilation of nitrogen by rice *Hawai Agri. Expt. Sta. Bull.* **24.**
9. Lorenz, O. A. & Johnson, C.M. 1953. Nitrogen fertilization as relation to the availability of phosphorus in certain california soils. *Soil Sci.*, **75**: 119-129.
10. Piper, C. S. 1950. Soil & Plant analysis. University Adelaide.
11. Raychaudhury, S. P. 1952. Chemical fertilizers and soil productivity. *Ind. J. Agric. Sci.*, **22** (3): 223-234.
12. Satyanarayanum, P. 1958. Fertilizer News letter No. 1, 2 & no. 11.
13. Sen, J. N. 1916. A study in the assimilation of nutrients by rice plant *Imp. Agr. Res. Inst. Pusa. Bull.*, **65.**
14. Sturgis, M. B. & Reed Fielding, J. 1937. The relation of organic matter and fertilizer to the growth and composition of rice. *J. Amer. Soc. Agron.* **29**: 360-366.
15. Troug, E. 1930. *J. Amer. Soc. Agron.*, **22**:874.
16. Yates, F.; Finney, D. J. & Panse, V. G. 1953. The use of fertilizers on food grains. *I. C. A. R. Research Serv.*, **1**:1-20.

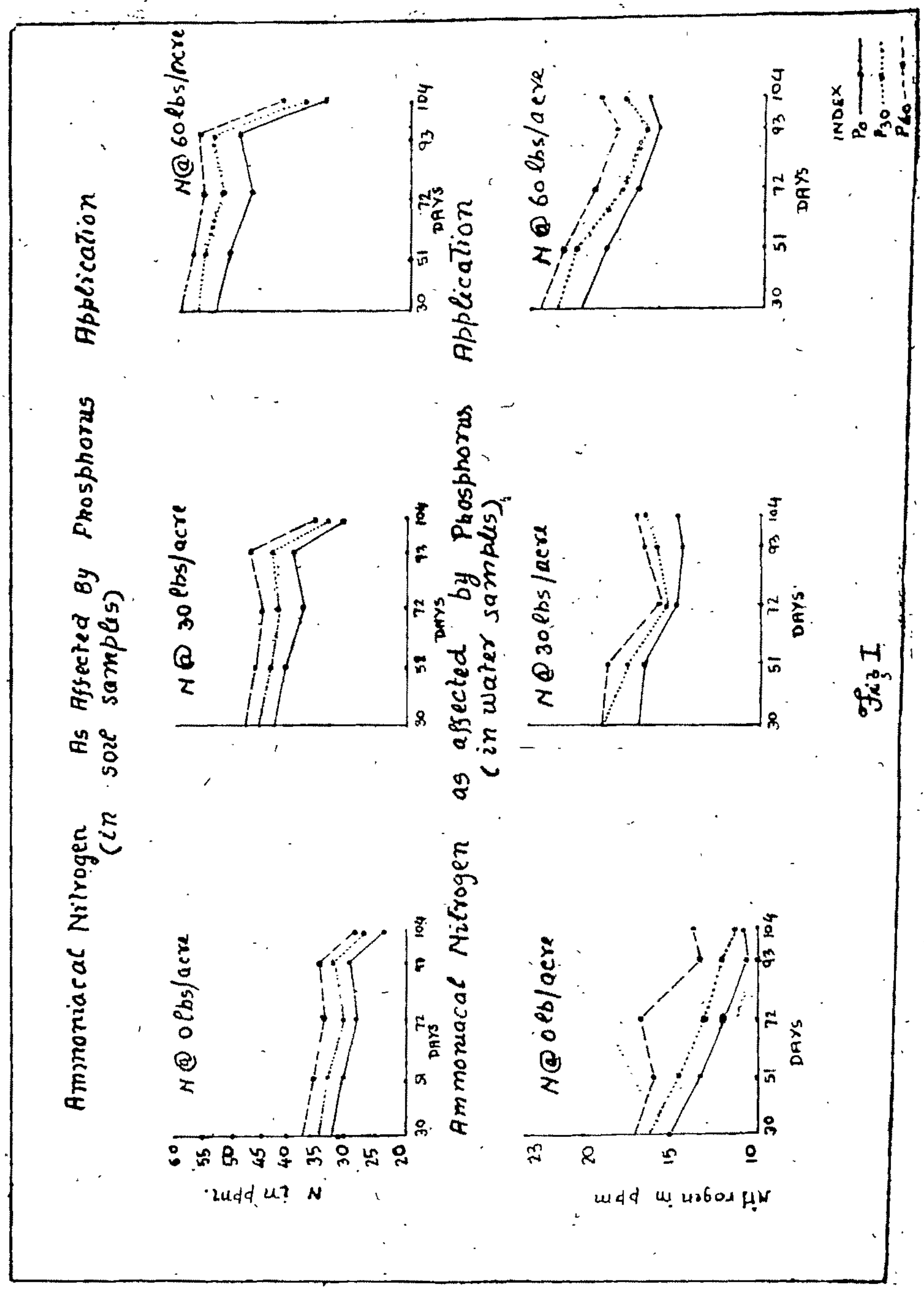


Fig I

Errata *Add* (Fig. I and II) after, ppm respectively but before (.) in line 3 of last para on page 82.

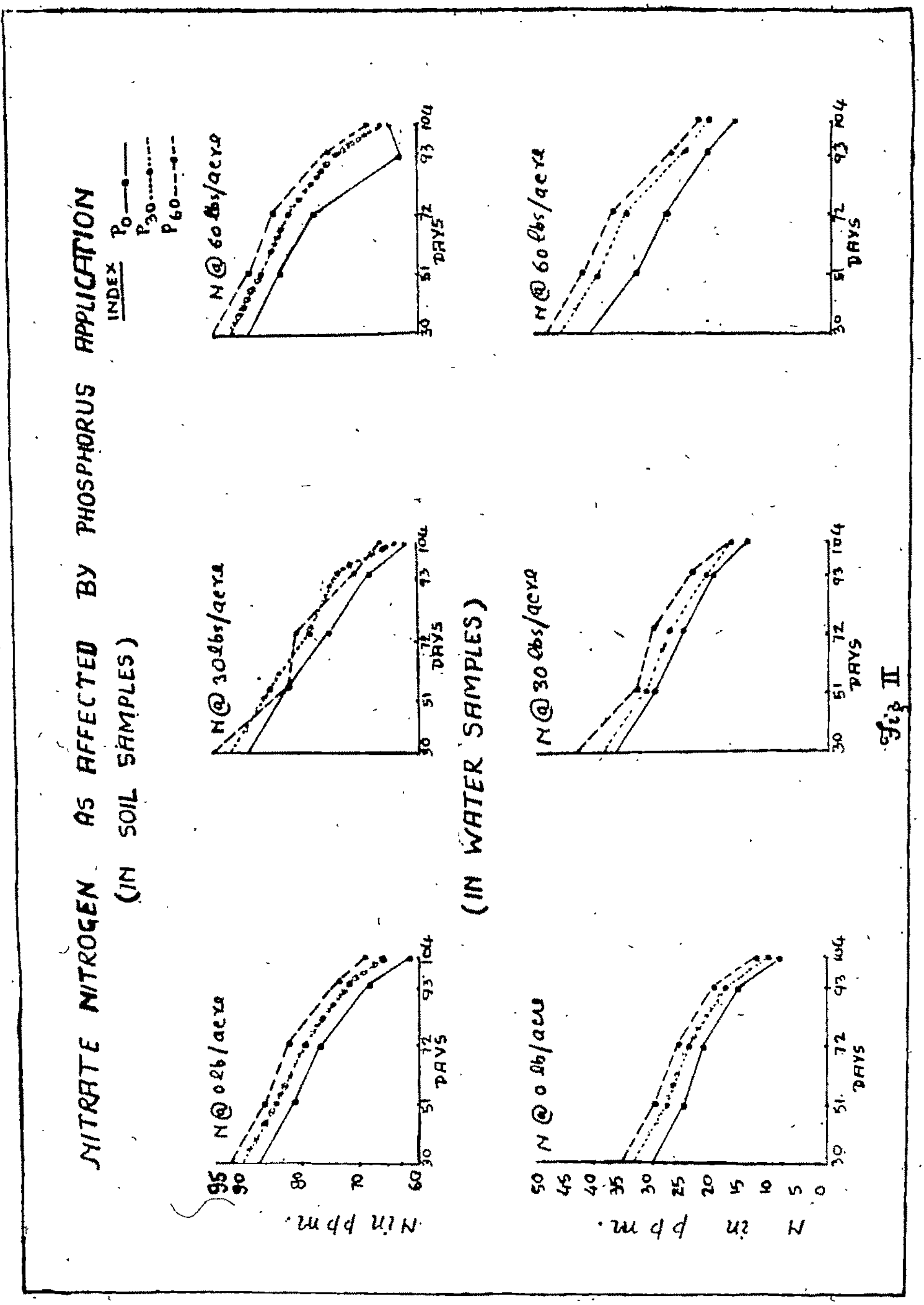


Fig. II

Add (Fig. II) between words NO$_3$-N.........in soil in line 8 of last para on page 82.
,, (Fig. II) in the end of second para on page 83 after, days of sampling.

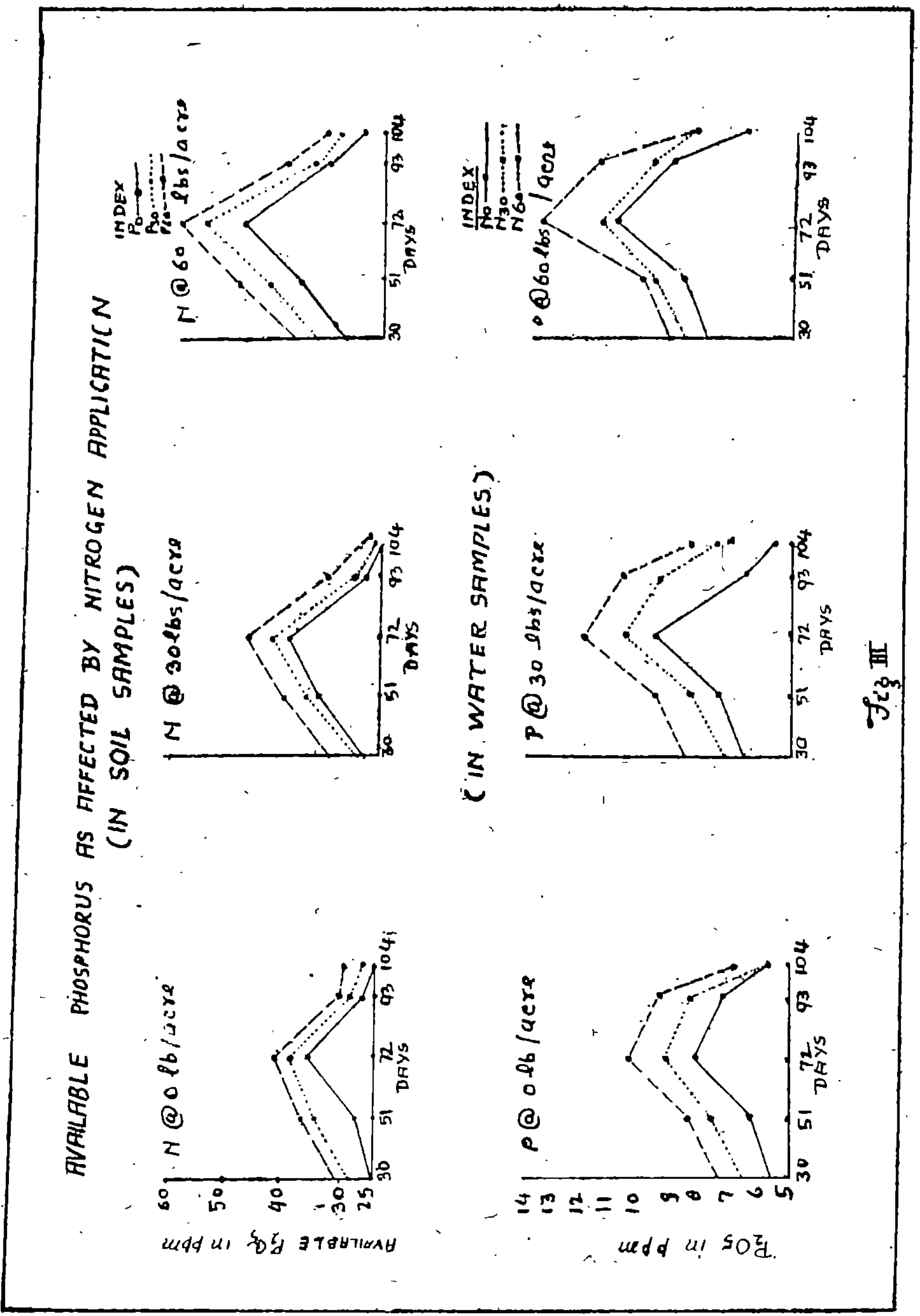
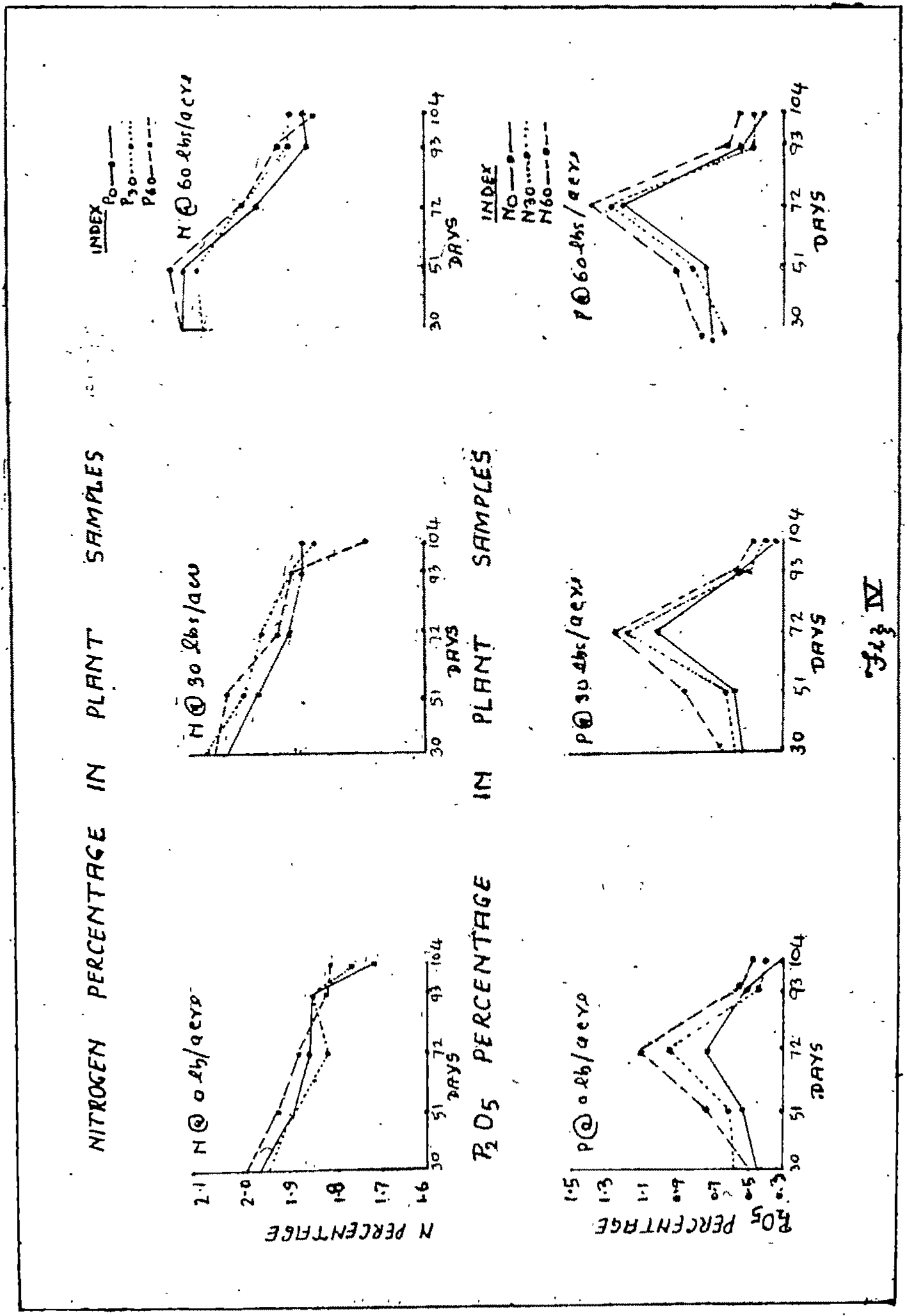


Fig III

Add (Fig. III) after the word, soil in line 3 of para III beginning with *Available P in soil and water* on page 83.


NITROGEN PERCENTAGE IN PLANT SAMPLES

P_2O_5 PERCENTAGE IN PLANT SAMPLES

Fig. IV

Add (Fig. IV) in between the words, seen......that in line one of the fifth para on page 83.
,, (Fig. IV) after the word growth in line 3 of para sixth on page 83.

ADVANCEMENT OF FLUID OVER AN INFINITE PLATE BOUNDARY LAYER THEORY

RAM GOPAL SHARMA
Department of Mathematics, Agra College, Agra.

SUMMARY

Nigam[2] (1951) has considered the advancement of fluid over an infinite plate. He obtained the approximate values of u and v in forms of definite integrals, perhaps to be evaluated by numerical analysis. In another paper Nanda and Jain[1] (1961) considered the same problem and they integrated the non-linear equation by numerical analysis. Here we have considered the same problem and have been able to obtain the expressions for u and v in exact forms.

INTRODUCTION

An infinite plate $y=0$ is placed on the zx-plane. x-axis is taken along the length of the plate and y-axis perpendicular to it. At the time $t=0$ the fluid occupies a vast expanse of space, for which $x \leqslant 0$ and the front surface of the fluid, the plane $x=0$, starts moving with a constant velocity U_0 in the x-direction. The front surface distance from the origin is always $u_0 t$ at time t.

EQUATIONS OF MOTION

The boundary layer equation is

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \nu\frac{\partial^2 u}{\partial y^2} \qquad ..(1)$$

The equation of continuity is

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \qquad ..(2)$$

where u, v are components of velocity in the direction of x-axis and y-axis respectively, ν is the kinematic coefficient of viscosity. Now assume that

$$\left.\begin{aligned} &\psi = \sqrt{\nu U_0(U_0t-x)}\, f(\eta) \\ &\text{where} \quad \eta = \frac{y}{\sqrt{\frac{\nu}{u_0}\,(U_0t-x)}} \end{aligned}\right\} \qquad ..(3)$$

$$\text{Therefore } u = \frac{\partial\psi}{\partial y} = \sqrt{\nu U_0\,(U_0t-x)}\; f'(\eta)\, \frac{1}{\sqrt{\frac{\nu}{U_0}\,(U_0t-x)}}$$

$$= u_0 f'(\eta) \qquad ..(4)$$

$$v = -\frac{\partial\psi}{\partial x}$$

$$=\tfrac{1}{2}\frac{\sqrt{\nu u_0}\,f(\eta)}{\sqrt{(v_0t-x)}}-\sqrt{\nu u_0\,(u_0t-x)}\,f'(\eta).\ \frac{y}{\sqrt{\dfrac{\nu}{u_0}}}\,\frac{1}{(u_0t-x)^{\frac{3}{2}}}$$

$$=\tfrac{1}{2}\left(\frac{\nu u_0}{u_0t-x}\right)^{\frac{1}{2}}\Big[f(\eta)-\eta f'(\eta)\Big] \qquad ..(5)$$

The equation (1) then becomes

$$2f'''-ff''+\eta f''=0 \qquad ..(6)$$

where dashes denote the differentiation with respect to η.

BOUNDARY CONDITIONS

The boundary conditions are :

$u=0=v$ on $y=0,\ x\leqslant u_0t$

i.e. $f(0)=f'(0)=0$

and $u=u_0$ for $y=\infty,\ x\leqslant u_0t$

i.e. $f'(\infty)=1$

and $u=u_0$ for $x=u_0t$ for $y>0$.

Solution :

Substituting $\eta=2\xi$, the equation (6) becomes

$$f'''+2\xi f''-ff''=0 \qquad ..(7)$$

where dashes denote differentiations with respect to ξ. The solution of (7) with appropriate boundary conditions is

$$f=2\xi\ \text{erf}\,\xi+\frac{2}{\sqrt{\pi}}\left(e^{-\xi^2}-1\right)+\frac{4}{\sqrt{\pi}}\int_0^{\xi}\Bigg[\frac{\sqrt{\pi}}{8}(\text{erf}\ \xi)^2-\tfrac{1}{4}\,\xi e^{-\xi^2}$$

$$\text{erf}\ \xi-\frac{1}{4\sqrt{\pi}}e^{-2\xi^2}+\frac{1}{2\sqrt{\pi}}e^{-\xi^2}+\frac{2-\pi}{8\sqrt{\pi}}\text{erf}\ \xi-\frac{1}{4\sqrt{\pi}}\Bigg]d\xi \qquad ..(7)$$

$$=2\xi\ \text{erf}\ \xi+\frac{2}{\sqrt{\pi}}\left(e^{-\xi^2}-1\right)+\frac{4}{\sqrt{\pi}}\Bigg[\frac{\sqrt{\pi}}{8}\Big\{\xi\ \text{erf}^2\xi+$$

$$\frac{2}{\sqrt{\pi}}\text{erf}\,\xi.\,e^{-\xi^2}-\frac{2}{\sqrt{\pi}}\text{erf}\,(\sqrt{2}\,\xi)\Big\}_0^{\xi}-\tfrac{1}{4}\Big\{-\tfrac{1}{2}\ \text{erf}\,\xi\,e^{-\xi^2}+\tfrac{1}{2}\ \text{erf}\,(\sqrt{2}\,\xi)\Big\}_0^{\xi}$$

$$-\frac{1}{4\sqrt{\pi}}\Big\{\frac{\sqrt{\pi}}{2}\,\text{erf}\,(\sqrt{2}\,\xi)\Big\}_0^{\xi}+\tfrac{1}{4}\Big\{\text{erf}\,\xi\Big\}_0^{\xi}$$

$$+\frac{2-\pi}{8\sqrt{\pi}}\Big\{\xi\ \text{erf}\,\xi+\frac{1}{\sqrt{\pi}}e^{-\xi^2}\Big\}_0^{\xi}-\frac{1}{4\sqrt{\pi}}\Big\{\xi\Big\}_0^{\xi}\Bigg] \qquad ..(8)$$

$$= \left(2+\frac{2-\pi}{2\pi}\right)\xi \operatorname{erf}\xi+\left(\frac{2}{\sqrt{\pi}}+\frac{2-\pi}{2\pi^{\frac{3}{2}}}\right)e^{-\xi^2}-\left(\frac{2-\pi}{2\pi^{\frac{3}{2}}}+\frac{2}{\sqrt{\pi}}\right)$$

$$+\tfrac{1}{2}\xi \operatorname{erf}^2\xi+\left(\frac{1}{\sqrt{}}+\frac{1}{2\sqrt{}}\right)\operatorname{erf}\xi e^{-\xi^2}$$

$$-\frac{2}{\sqrt{\pi}}\operatorname{erf}(\sqrt{2}\,\xi)+\frac{1}{\sqrt{\pi}}\operatorname{erf}\xi-\frac{1}{\pi}\xi.$$

$$=\frac{3\pi+2}{2\pi}\xi \operatorname{erf}\xi+\frac{3\pi+2}{2\pi^{\frac{3}{2}}}e^{-\xi^2}-\frac{2+3\pi}{2\pi^{\frac{3}{2}}}+\tfrac{1}{2}\xi \operatorname{erf}^2\xi$$

$$+\frac{3}{2\sqrt{\pi}}\operatorname{erf}\xi\, e^{-\xi^2}-\frac{2}{\sqrt{\pi}}\operatorname{erf}(\sqrt{2}\,\xi)+\frac{1}{\sqrt{\pi}}\operatorname{erf}\xi-\frac{1}{\pi}\xi. \qquad ..(9)$$

Differentiating (7) we get

$$f'=2\operatorname{erf}\xi+\frac{4}{\sqrt{\pi}}\xi e^{-\xi^2}-\frac{4\xi}{\sqrt{\pi}}e^{-\xi^2}+\tfrac{1}{2}(\operatorname{erf}\xi)^2-\frac{1}{\sqrt{\pi}}\xi e^{-\xi^2}\operatorname{erf}\xi-\frac{1}{\pi}e^{-2\xi^2}$$

$$+\frac{2}{\pi}e^{-\xi^2}+\frac{2-\pi}{2\pi}\operatorname{erf}\xi-\frac{1}{\pi} \qquad ..(10)$$

From (9) and (10) it can be verified that

$$f(0)=f'(0)=0$$

$$\text{and } f'(\infty)=2.$$

Here (9) and (10) satisfy boundary conditions.

$$u=u_0\Big[\,2\operatorname{erf}\xi+\frac{4}{\sqrt{\pi}}\xi e^{-\xi^2}-\frac{4\xi}{\sqrt{\pi}}e^{-\xi^2}+\tfrac{1}{2}(\operatorname{erf}\xi)^2-\frac{1}{\sqrt{\pi}}\xi e^{-\xi^2}\operatorname{erf}\xi$$

$$-\frac{1}{\pi}e^{-2\xi^2}+\frac{2}{\pi}e^{-\xi^2}+\frac{2-\pi}{2\pi}\operatorname{erf}\xi-\frac{1}{\pi}\Big] \qquad ..(11)$$

$$v=\tfrac{1}{2}\left(\frac{\nu u_0}{u_0 t-x}\right)^{\frac{1}{2}}\Big[\frac{3\pi+2}{2\pi^{\frac{3}{2}}}e^{-\xi^2}-\frac{2+3\pi}{2\pi^{\frac{3}{2}}}+\frac{3}{2\sqrt{\pi}}\operatorname{erf}\xi e^{-\xi^2}$$

$$-\frac{2}{\sqrt{\pi}}\operatorname{erf}(\sqrt{2}\,\xi)+\frac{1}{\sqrt{\pi}}\operatorname{erf}\xi-\frac{1}{\pi}\xi e^{-\xi^2}-\frac{4}{\sqrt{\pi}}\xi^2 e^{-\xi^2}$$

$$+\frac{1}{\sqrt{\pi}}\xi^{3}e^{-\xi^2}\operatorname{erf}\xi\Big] \qquad ..(12)$$

Thus the components of velocity have been exactly obtained.

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REFERENCES

1. Nanda & Jain. 1961. *Jour. of Sci. & Engg. Res.* pp. 279-284.
2. Nigam, S.D. 1951. *Bull. Call. Maths Sco.* **43** : (I) 150.

Abstract of Theses

THE FISHERMEN CO-OPERATIVE SOCIETIES OF VISAKHAPATNAM DISTRICT*

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Co operation makes very little effective appeal to the desparately poor, as also to the very rich. The one is too weak to successfully evoke any measure of self-help, the other is too strong economically to need any collective aid, as the fishermen community belong, for the most part, to the former category, Co-operation has not made any appreciable progress among them. The progress made in this district are :—

Credit Co-operatives :

As in other fields, the first type of Societies to be started for fishermen was mainly the credit Co operatives. Little attempt was made to pool, process and sell the member's catches. This was largely owing to the difficulties of acquiring fish-curing yards, where salt could be had at concessional rates and inadequate transport arrangements for marketing fish in distant areas. There were 22 (9 inland and 13 Marine) societies in Visakhapatnam district during 1961-62. The total members in these societies are 8220 and their share capital is Rs. 43,140 (Statement No. 1).

It has, however, been realised that credit by itself will not be a solution of the problem, and unless the fishermen are organised both for the purchase of their necessaries, as well as the sale of their catch, their economic condition will not materially improve; increasing attempts are therefore being made to link credit with purchase of requisites on the one hand and sale of the produce on the other.

Help in production and purchase:

One of the most common ways in which the fishermen have become indebted is by having to purchase their necessities from unscrupulous local merchants. Some of the societies, in addition to supply of credit, undertake the purchase and distribution of domestic requirements to the fishermen. Many of the societies are also actively helping the members in the purchase of their production requirements. The State Government has also given at cheap rates the raw materials required by them such as hemp, hook, tar, improved types of fishing boats with oil engines etc.

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Assistance in marketing :

The model bye-laws for fishermen Co-operative Societies, inter alia, contain provisions for the joint sale of the members produce. The principle of "Controlled-Credit" so successful in the field of agricultural credit, is being in a way extended to some of the fishermen's Societies also.

Welfare activities :

In a community so backward in every respect, and depending ordinarily on such a precarious and narrow means of livelihood, it is hardly to be expected that self-help organisation will be able to find either the resources from among themselves, or the necessary personnale to undertake welfare work on anything like the scale required by the community. Such work like education, provision of housing, medical welfare, health and sanitation arrangements, and other ameliorative measures, have, therefore, to be undertaken by the public bodies.

The working of the fishermen Co-operative Societies has shown the possibilities in this direction, and with more propaganda, careful planning and spread of education there appears to be very good scope for the setting up of new societies and expanding the activities of those already in operation.

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We are indebted to Dr. R. D. Saksena, Professor and Head of the Department of Zoology, B. R. College, Agra without whose co operation this work could not have been carried out.

REFERENCES

1. Government of India, 1958. Co-operatives as a means of preservation of Fishery Development. *F. A. O. Publication No. 9.*
2. Szezepanik, E. 1958. Report of the F.A.O. Training Centre Fishery Co-operative and Administration. *F. A. O. Publication,* Vol. I & II.
3. Szezepanik, E. 1960. The economic role of middlemen and Co-operation in Indo-Pacific Fisheries. *F. A. O. Publication.* 1960.

STATEMENT No. 1

Statement showing the Fishermen Co-operative Societies at Visakhapatnam District during 1961-1962.

Name of the village	Inland	Marine	Members	Share capital (in Rs.)
1. *Visakhapatnam Taluk*				
Lawson's Bay	...	1	752	1,097·00
Kothvalampeta	...	1	704	3,520·00
Gangavaram	...	1	601	1,552·00
Atchiyamma Peta	1	...	200	1,070·00
2. *Bhimunipatnam Taluk*				
Chintapalli	...	1	1,000	5,250·00
Mukkam	...	1	654	8,270·00
Bhogapuram	1	...	100	500·00
Bhimunipatnam	...	1	541	2,304·00
M. G. Peta	...	1	213	1,050·00
3. *Anakapalli Taluk*				
Pudimadaka	...	1	261	1,370·00
Kondakarla	1	...	100	500·00
4. *Elamanchili Taluk*				
Kothapatnam	...	1	1,194	6,050·00
Polavaram	...	1	140	2,370·00
Rajayyapeta	...	1	140	2,370·00
Pentakota	...	1	408	1,040·00
5. *Srungavarapukota Taluk*				
Yerrahpalem	...	1	228	1,197·00
Lakkavarapukota	1	...	100	500·00
Annampeta	1	...	200	1,070·00
6. *Vizianagaram Taluk*				
Vizianagaram	1	...	27	500·00
Bondapalli	1	...	120	600·00
7. *Chodavaram Taluk*				
Chodavaram	1	...	100	500·00
Rongalanaidu palem	1	...	100	500·00
Total	9	13	8,220	43,140·00

STUDIES ON THE SERO-DIAGNOSTIC ASPECT OF RINDERPEST VIRUS*

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ABSTRACT

The aim of this study was to explore the possible application of various serological tests and to find out one which is rapid and specific in the diagnosis of rinderpest. Attempts were also made to determine the immune status of cattle by intradermal allergic test.

In this study a total of 126 tissue samples from infected goats used for production of vaccine at Biological Products Section, U.P., Lucknow, and 94 sera samples from experimental and those vaccinated with Goat Tissue Virus were examined for their serological reaction by gel diffusion and complement fixation test.

Gel diffusion test was found satisfactory method for the demonstration of rinderpest antigen and antibody. Fifty-five out of 101 lymph node extracts gave positive precipitation reaction by gel diffusion method. Regular reinforcements were needed with antigen and antibody to obtain a positive reaction. Out of those giving a positive reaction twenty-six gave two distinct precipitation lines while the rest gave only one line.

No significant correlation was found between temperature range of slaughtered goats and those giving a positive precipitation reaction. Maximum reactions were obtained between 24-48 hours when incubation was carried out at 22-26°C.

The precipitating antibody was demonstrable from 10th to 21st and 28th to 31st days in the sera of calves inoculated with a single injection of bull virus and with repeated injections of caprinised virus respectively.

Both direct and indirect haemagglutination tests failed to demonstrate the haemagglutination property of rinderpest virus.

The intradermal allergic test as described appears to be a suitable method in assessing the immune status of cattle.

Complement fixation test adopted in this study was found satisfactory. The specific complement fixing rinderpest antigen was demonstrable in 99 out of 100 boiled extracts of infected lymph nodes with one hour fixation at 37°C.

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* An abstract of the thesis submitted to the Agra University in partial fulfilment of the requirements for the award of M. V. Sc. degree in Bacteriology.

Complement fixing antibody was demonstrable from 14th day upto 60 days, the period under observation, in a baffalo calf inoculated with bull virus. Serum collected on 28th and 31st day from another buffalo calf which was given a course of injections of caprinised virus gave good complement fixation reaction. Specific rinderpest antibody was demonstrable in the sera of cattle vaccinated with goat attenuated virus from 4th week to 8th week, the period under test.

Among the serological tests conducted, the complement fixation test appears to be reliable and rapid method in the diagnosis of rinderpest. In a suspected outbreak efforts should be concentrated on the detection of specific antigen in boiled extracts of lymph node, to avoid any non specific reactions.

Some serological relationship has been observed between rinderpest virus and viral diarrhoea virus (Oregan C24V strain). This needs more work for further clarification.

ISOLATION AND IDENTIFICATION OF BACTERIAL AND VIRAL AGENTS FROM RESPIRATORY TRACT OF SWINE*

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The problem was selected to have a first hand information about the type and the extent of the incidence of the respiratory tract of pigs due to infectious agents. The materials were mostly collected from central Dairy Farm, Aligarh and local breeders. For the isolation and characterization of aerobic and micro-aerophilic bacteria and viruses. The materials include nasal swabs, trachea and lungs.

Three hundred and seventeen specimens of normal and pneumonic lungs, trachea and nasal swabs were collected from pigs for the isolation of bacteria and viruses.

Out of 101 specimens of nasal swabs and 108 specimens each of trachea and lungs, 103, 84 and 136 bacterial strains respectively were isolated. No organism could be isolated from 7 samples of nasal cavity, 13 samples of trachea and 10 samples of lungs.

Out of 105 cocci 11 (10·4%) were identified as *staph, aureus*, 12 (11·4%) *Staph. albus*, 8 (7·6%) *Staph. citreus*, 26 (24·7%) beta haemolytic Streptococci, 21 (20%) alpha haemolytic Streptococci and 21 (20%) non-haemolytic Streptococci.

Among 91 gram positive rods 2 (2·1%) were typed as *Listeria monoytog-nes*, 7 (7·6%) *C. equi*, 18 (19·7%). *C. pyogenes* 15 (16·4%) other diphtheroids, 7 (7·6%) Cellulomonas and 19 (10·9 %) anthracoids. Thirty-two (35·1%) gram positive rod shaped organisms could not be typed.

One hundred-twenty and seven gram negative rod shaped organisms were identified as *sal. cholerae suis* 4 (3·1%), Proteus,. *E. coli* 12 (9·4%) Klebsiella 17 (13·2%), Paracolon 3 (2 3%), *B alkaligenes* 15 (11·8%), Pseudomonas 10 (7·8%), *Past. multocida* 23 (18·1%), *Past. Haemolytica* 15 (11·8%) *H. influenzae suis* 1 (0·7%) and other organisms somewhat similar to Haemophilus 5 (3·9%). Eighteen gram negative rod shaped bacteria could not be typed.

Ten pooled samples each consisting of 10 lungs, 10 trachea and 10 nasal swabs, and the eleventh pooled inoculum consisting of 8 lungs, 8 trachea and three nasal swabs were processed for the isolation of viruses after adding 10,000 unit/ml. of penicillin and 25 mg./ml. of streptomycin. Each polled inoculum was given three blind passages by yolk sac, C.A.M. and C.C.A. routes. Except the 10th and 11th polled inocula which cause some embryo mortality and their allantoic fluid gave H.A. test against chicken red blood cells, the processing of other inocula were given up. Most of the further studies were restricted on the agent isolated from polled specimen No. 11. The filtrable agent isolated from 10th pooled specimen could not be further studied due to nonavailability of time.

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The agent which was responsible for the congestion and mortality in the chicken embryos was not identified as bacteria or P.P.L.O. It was filterable through E.K. Seitz filter pads, gave positive haemagglutination with chicken, guinea pig, human 0, pigeon and goat red blood cells, H.A. test was inhibited by specific hyper-immune serum. The agent gave one precipitation line against specific serum by gel diffusion test. It was not susceptible to penicillin (10,000 units/ml.) and streptomycin (25 mg./ml.) and was labile to 20 per cent diethyl ether, to the buffer solution of pH_3 and also to 30 minutes inactivation at 50°C.

The agent when injected in pigs either alone or with *H. influenzae suis* could not produce distinct pathogenicity. Injected mice also did not show any clinical symptoms. Histo-pathologically there was a mild reaction in a portion of the apical lobe of the piglet which showed slight lymphocytic infilteration in perivascular spaces of blood vessels and alveoli.

The characteristics of the virus indicate that probably it belongs to the influenza group of the Myxo virus group.